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NATURAL HISTORY OF ANIMALS.

THE

NATURAL HISTORY OF ANIMALS;

BEING THE SUBSTANCE OF

THREE COURSES OF LECTURES

DELIVERED BEFORE

THE ROYAL INSTITUTION OF GREAT BRITAIN.

BY

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VOLUME TWO:

WITH ONE HUNDRED AND FOUR ENGRAVINGS.

LONDON:
JOHN VAN VOORST, PATERNOSTER ROW.
M.DCCC.LII.

LONDON:
Printed by SAMUEL BENTLEY and Co.,
Bangor House, Shoe Lane.

CONTENTS.

CHAPTER I.

PAGE
INTRODUCTION 1

CHAPTER II.

ON THE ORGANIZATION OF INSECTS . . . 23

CHAPTER III.

METAMORPHOSIS OF INSECTS 41

CHAPTER IV.

DISTRIBUTION OF INSECTS 59

CHAPTER V.

INSECT INSTINCTS 82

CHAPTER VI.

COLEOPTERA.—BEETLES 110

CHAPTER VII.

EARWIGS, COCKROACHES, LEAF-INSECTS, GRASSHOPPERS, CRICKETS, AND LOCUSTS,—THEIR HISTORY AND METAMORPHOSES 132

CHAPTER VIII.

HOMOPTEROUS INSECTS. — APHIDES, LANTERN-FLIES, FROG-HOPPERS, PSYLLÆ, OR BLIGHT-FLIES.—COCCI, OR COCHINEAL INSECTS, CICADÆ, ETC. . . . 153

CHAPTER IX.

PAGE
HETEROPTEROUS INSECTS.—NOTONECTÆ, OR WATER-BOATMEN.—HYDROMETER.—NEPA, OR WATER-SCORPION; AND ON THE CIMICES, OR BUGS, REDUVIUS, ETC. . . . 171

CHAPTER X.

NEUROPTEROUS INSECTS.—TERMITE ANTS.—EPHEMERON.—DRAGON FLIES, ETC. 180

CHAPTER XI.

PHRYGANEÆ, OR CADDIS FLIES 204

CHAPTER XII.

HYMENOPTEROUS INSECTS.—ANTS, WASPS, HORNETS, ETC.—HISTORY OF THE HIVE-BEE . . . 213

CHAPTER XIII.

STREPSIPTERA.—XENOS AND STYLOPS 254

CHAPTER XIV.

APHANIPTERA 261

CHAPTER XV.

DIPTEROUS INSECTS 266

CHAPTER XVI.

ARACHNIDA 315

CHAPTER XVII.

CRUSTACEA 355

THE

NATURAL HISTORY OF ANIMALS.

Of all the varied hues,
Their beauty-beaming parent can disclose,
Ten thousand forms! Ten thousand different tribes!
THOMSON.

In every community, whether large or small, the comfort, and even the subsistence of the general body must depend upon a zealous co-operation of the members composing it, each individual labouring in his appointed sphere of usefulness, and in proportion as the varied duties which thus devolve upon different classes, are faithfully or negligently performed, will the well-being of the whole be secured or endangered.

With the advance of civilization among mankind, the division of labour, and the apportioning to each grade of society its proper field for exertion, becomes progressively more and more precise, and although few but the most enlightened legislators can understand the mutual bearings and relationships of all parts of the grand scheme, every one participates in the benefits that accrue from the harmonious adaptation of the whole.

In no community therefore, however extensive, can any individual justly regard himself as absolved from that strict discipline on which so much depends, because the scope and design of it may to him appear incomprehensible—all nature teaches that no creature is unimportant to the general good, all are alike contributing to one great result, under supreme direction, and although the reins that govern may remain unseen, their efficacy becomes manifest from the felicity of their guidance.

It is oftentimes, and justly, a subject of wonder to any thinking mind, how, in a vast metropolis, provision can be made for the subsistence and comfort of the multitude of its inhabitants, and by what means so much security and social order can be preserved amongst them. Some persons, we are aware, seem to believe this to be the natural condition of things, and would be as much astonished any morning to find no fish upon the fishmongers' stalls, no meat at the butchers', or no vegetables in the market, as if the sun were to forget to rise at his usual hour, little thinking how extensive and intricate are the commercial relations that must be established, how numerous the agencies employed, before such conveniences can be secured. So it is in the grand economy of nature, millions of creatures

"walk the earth
Unseen, both when we wake, and when we sleep,"

each one of them labouring in its appointed vocation, and all unconsciously assisting in the establishment of that beauty and order which are everywhere conspicuous.

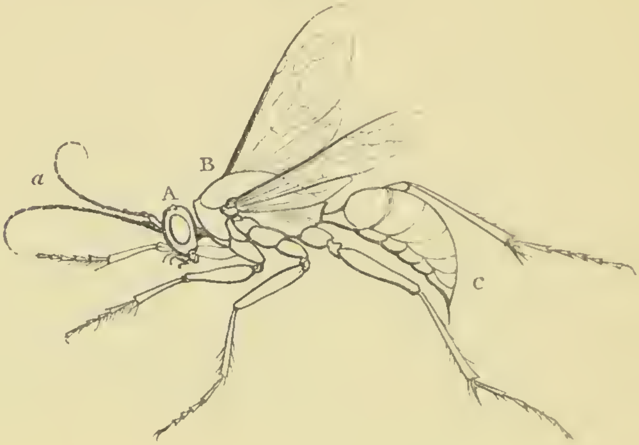
Among the most important of these agents of Nature, are the innumerable races of the insect world, creatures specially organized for the performance of multifarious and important duties, that could scarcely be intrusted to less vigilant officers.

The term Insect originally signified, any animal having its body composed of successive rings or segments, so that, in common language, most dissimilar and discordant forms of beings are still grouped together under this general appellation—it will, therefore, be necessary, before proceeding further, to define exactly what are the characters whereby a true insect is distinguishable from all other annulose creatures.

In describing the Myriapoda, we observed in a former chapter that the long and flexible bodies of the Centipedes are composed of numerous successive segments, all nearly similar to each other, and provided with jointed legs, adapted for crawling upon the surface of the ground. The insect, properly so called, has its body specially constructed with a view to its being furnished with *wings* in addition to the usual ambulatory limbs, and is thus enabled to make its way, borne upon the thin medium of the air, a mode of progression that requires the most vigorous exertion of muscular strength; the insect must, therefore, be provided with a proper frame-work appropriated to sustain the instruments of flight, and possessed of sufficient strength to support the energetic action of the powerful muscles that move the wings.

The first great character, therefore, peculiar to the insect in its adult state, is the division of its

Fig. 1.

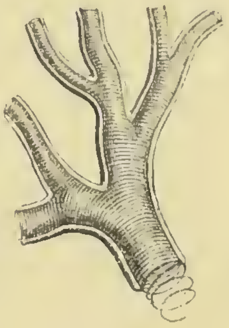


body into three principal regions, namely the Head (fig. 1, A), containing the organs of the senses, the Thorax (B), which sustains the locomotive apparatus; and the Abdomen (C), wherein are lodged the nutritive and other bulky viscera. A second character, equally indispensable to the true insect, is, that it shall, when mature, be furnished with *only* six legs, all attached to the thorax. These, as we shall afterwards see, present infinite variety as relates to their mechanical structure, whereby they become adapted to the varying conditions under which each race of insects lives, but their number is invariably *six* throughout the whole class. A third peculiarity, but by no means so constant as the last two, is the possession of wings. These, when present, are for the most part four in number, but in one extensive order (DIPTERA), a single pair only is allowed. Very frequently, when powers of flight are not required, the wings are never developed, for reasons which we shall hereafter have an opportunity of examining. If, to the above characters, we add that an insect has invariably *two* jointed organs attached to the head, named its *antennæ* or *feelers* (fig. 1, *a*), our definition is sufficiently complete for our present purpose, and there will be little danger of our confounding other articulated animals with insects zoologically entitled to that name.

All insects, even those that live in water, are essentially air-breathing, and the mode in which they respire is another important feature of their economy. Along the sides of the abdomen, and likewise of the thorax, is placed a series of minute orifices, called spiracles, generally nine or ten in number, each surrounded with a prominent valvular ring, and so constituted as to be opened or shut at the pleasure of the little animal. Every spiracle communicates with an amazing apparatus of breathing tubes or *tracheæ*, which ramify profusely through all parts of the insect's body, branching out among the different organs in every possible direction, and thus serving to diffuse atmospheric air wherever they penetrate, exactly in the same manner as the pipes in our streets distribute gas or water through every district of our towns. Various important objects are at once obtained by the establishment of this novel form of respiratory apparatus among the insect races;—pure air being thus copiously admitted to every part, the circulating fluids are everywhere continually exposed to the influence of the atmosphere, and all necessity for the existence of the more cumbersome breathing organs required by other animals is at once obviated. The included air, moreover, being to a certain extent heated and rarified in its passage through the tracheal canals, positively tends still further to lighten the bodies of these exquisitely organized beings, and to fit them for the performance of those rapid evolutions for which the generality of them are so remarkable.

There is one elegant arrangement connected with the breathing-tubes of an insect, specially worthy of admiration, and perhaps in the whole range of animal mechanics it would be difficult to point out an example of more exquisite mechanism, whether we consider the object of the contrivance, or the remarkable beauty of the structure employed. The air-tubes themselves are necessarily extremely thin and delicate, so that on the slightest pressure their sides would inevitably collapse, and thus completely put a stop to the passage of air through them, producing, of course, the speedy suffocation of the insect, had not some means been adopted to keep them always permeable, and yet to do so, and at the same time to preserve their softness and perfect flexibility, might seem a problem not easily solved. The plan adopted, however, fully combines both these requisites. Between the two thin layers of membrane which form the walls of every air-tube, a delicate elastic thread (a wire of exquisite tenuity) has been interposed, which, winding round and round in close spirals, (fig. 2), forms, by its revolutions, a cylindrical pipe of sufficient firmness to preserve the air-vessel in a permeable condition, whilst at the same time it does not at all interfere with its flexibility; this fine coil is continued through every division of the tracheæ, even to their most minute ramifications, a character whereby these vessels are readily distinguishable, when examined under the microscope.

Fig. 2.



Fully commensurate with this extraordinary perfection of the breathing apparatus, is their muscular power as well as the celerity of their movements. Few of us suspect while we amuse ourselves with watching the active gambols of the tiny beings, that to enable them to perform such feats as we see them execute every day, an amount of strength has been conferred upon them which could not safely have been entrusted to any of the larger animals, and that nothing but the comparatively diminutive size to which all the insect races are jealously restricted, prevents them from becoming the tyrants of this globe and the destroyers of all other terrestrial creatures. The fables of antiquity have seldom ventured to attribute to the most redoubtable of mythological heroes such deeds as are every day performed before our own eyes; for the labours of Hercules, and the masonry of the Cyclops, equally sink into insignificance when compared with the most ordinary achievements of the members of the insect world.

Should any of our readers be sceptical upon this point, perhaps the following illustrations of super-herculean strength with which the commonest insects are endowed, selected from curious sources, may prepare us to credit more easily the facts which we shall have to record in subsequent pages. The common flea, as every one knows, will, without much apparent effort, jump two hundred times its own length, and several grasshoppers and locusts are said to be able to perform leaps quite as wonderful. In the case of the insect they scarcely excite our notice; but if a man were coolly to take a standing leap of three hundred and eighty odd yards, which would be an equivalent exertion of muscular power, perhaps our admirers of athletic sports might be rather startled at such a performance.

Again, for a man to run ten miles within the hour would be admitted to be a tolerably good display of pedestrianism; but what are we to say to the little fly observed by Mr. Delisle, "so minute as almost to be invisible," which ran nearly six inches in a second, and in that space was calculated to have made one thousand and eighty steps? This, according to the calculation of Kirby and Spence, is as if a man whose steps measured only two feet, should run at the incredible rate of twenty miles in a minute.

Equally surprising are the instances of insect strength given by Mr. Newport.* The great stag-beetle (*Lucanus cervus*, fig. 10), which tears off the bark from the roots and the branches of trees, has been known to gnaw a hole, an inch in diameter, through the side of an iron canister in which it was confined, and on which the marks of its jaws were distinctly visible, as proved by Mr. Stephens, who exhibited the canister at one of the meetings of the Entomological Society.

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* Cyclop. of Anat. and Physiol. Art. INSECTA.

The common beetle, *Geotrupes stercorarius*, can, without injury, support and even raise very great weights, and make its way beneath almost any amount of pressure. In order to put the strength of this insect-Atlas to the test, experiments have been made which prove that it is able to sustain and escape from beneath a load of from twenty to thirty ounces, a prodigious burden when it is remembered that the insect itself does not weigh as many grains; in fact, once more taking man as a standard of comparison, it is as though a person of ordinary size should raise and get from under a weight of between forty and fifty tons. This amount of strength is not, however, confined to the short thick-limbed beetles. Mr. Newport once fastened a small *carabus*, —one of the most active and elegantly formed of the beetle tribe,—which weighed only three grains and a-half, by means of a silk thread, to a small piece of paper, upon which the weight to be moved was placed. At a distance of ten inches from its load the insect was able to drag after it, up an inclined plane of twenty-five degrees, very nearly eighty-five grains; but when placed on a plane of five degrees inclination, it drew after it one hundred and twenty-five grains exclusive of the friction to be overcome in moving its load—as though a man was to drag up a hill of similar inclination, a waggon weighing two tons and a-half, having first taken the wheels off.

Such being the strength of insects as tested by their powers of leaping, running, tearing, carrying, and drawing, let us, in the last place, by way of completing our glance at this part of their economy, briefly advert to their capabilities in the way of flying, a mode of locomotion in which they likewise are unrivalled in the whole range of animated nature. In order to prove this, we need not search far. The common house-fly (*Musca domestica*) will answer our purpose as well as more striking examples. This familiar inmate of our dwellings has been calculated by a writer in "Nicholson's Journal"* to fly, when engaged upon ordinary business, at the rate of five feet in a second, but upon an emergency it will clear thirty or thirty-five feet in the same period. "In this space of time," to use the illustration adopted by Kirby and Spence, "a race-horse could clear only ninety feet, which is at the rate of more than a mile in a minute. Our little fly, in her swiftest flight, will in the same space of time, go more than one-third of a mile. Now compare the infinite difference of the size of the two animals (ten millions of the fly would hardly counterpoise one racer), and how wonderful will the velocity of this minute creature appear! Did the fly equal the race-horse in size, and retain its present powers in the ratio of its magnitude, it would traverse the globe with the rapidity of lightning."

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* Vol. iii. p. 36.

Gifted with such enormous power, and possessed of capabilities of flight so unheard of, it is a fortunate circumstance for the rest of the animal creation, that the dimensions of the various races of the insect-world, have been kept within safe limits. Let the reader conceive for a moment, this great law dispensed with but in a single instance; fancy the wasp or the stag-beetle dilated to the size of the tiger or the elephant, and still retaining its insect-attributes, augmented in proportion to its increased bulk, cased in impenetrable mail, against which all weapons would be unavailing, armed with jaws that would crush the solid trunk of an oak as though it were a radish, and so rapid in its movements, as to be literally able to "put a girdle round about the earth in forty minutes," what living beings could resist such an assailant, or hope to put a stop to its devastating career!

In estimating the nature of the senses of insects, the amount of their intelligence, and the modes whereby they hold communication with the external world, the naturalist soon finds that he has many insurmountable difficulties to encounter. In approaching this part of our subject, it is evident that it is only from analogies drawn from our own experience, that we can form any idea of the senses enjoyed by other animals; presuming, as we must do, that they are of a similar character to those which we ourselves possess. As well might we expect a person who had been born blind, or deaf, to entertain a just conception of the nature of light, or of the qualities of sound, as to hope to obtain a correct notion concerning sensations with which our appreciations have nothing in common. A very little reflection, indeed, will convince us, that most probably, senses are bestowed upon many animals widely different in their character from any of which we can form accurate notions.

That insects possess a general sense analogous to that of touch, we cannot for a moment doubt, notwithstanding the dense nature of the horn-like armour in which their bodies are usually encased, and that they are furnished likewise with special tactile organs, is hardly to be questioned, seeing that the antennæ (fig. 1, *a*), as well as similar structures called *palpi*, connected with the mouth, are constantly employed for the examination of external objects, but how far the information obtained by means of these instruments is identical with that afforded to us by our finger-ends, must obviously remain a matter of conjecture.

That many insects are endowed with the faculty of appreciating odours, we have undoubted evidence, but the most minute research and patient investigation have failed to detect the existence of anything like an organ of smell. The flesh-fly is evidently guided to the carrion in which her progeny is to be reared, by the stench that it exhales, a fact sufficiently proved by the circumstance, that so little does she care about any other condition, that she will deposit her maggots upon a cloth that has imbibed the taint of putrefaction, or even in certain fetid flowers, the odour of which is similar to that of putrid meat.

We must ever remain in ignorance whether they do or do not enjoy the luxury of appreciating savours; most probably, indeed, seeing the variety of food upon which they live, and the precision with which each species selects its own peculiar diet, such an indulgence is permitted. At least it would seem reasonable to suppose that the nectar from the flower-bell affords some sweetness to the butterfly, which sips it, and if the bread of labour be sweet, that the honey of the hive is not perfectly tasteless to the industrious bee; nevertheless the anatomist has not yet succeeded in demonstrating any part that can be specially regarded as a gustatory organ, or which offers a structure decidedly analogous to the tongue of higher animals. We are equally in the dark relative to the means whereby insects exercise the sense of hearing, although we cannot deny them the possession of this faculty also, seeing that not a few of them, such as the crickets, grasshoppers, cicadæ, and others, are positively furnished with musical instruments, wherewith to call or serenade their mates. There seems, indeed, reason to suppose that the perception of sound is in some way or other connected with those mysterious organs, the *antennæ*, but in what way, we are quite at a loss to explain.

Seeing, therefore, that insects apparently enjoy senses at least representing those conferred upon us, without our being able to discover anything at all like the instruments whereby such senses are ordinarily exercised, we ought to learn to be cautious in too hastily criticising the attributes of beings which differ so widely from ourselves in every part of their organization, and rest contented to be the humble students of Nature, instead of setting up, as is too much the fashion in modern times, to be the critics and the lawgivers of creation. Nothing perhaps is better calculated to teach us this great lesson than a review of what patient research has revealed to an astonished world, during the last few years, relative to the eyes of insects and the structure of their visual organs.* To our forefathers nothing seemed more simple and more natural than the supposition that insects in their perfect state possessed two eyes: fishes, quadrupeds, reptiles, and birds, all of them have two eyes; and if in addition to an analogy so general we were to trust to the evidence of our unassisted senses, we should decidedly be inclined to join with the older naturalists in asserting that insects had two eyes likewise. Nevertheless, however mortifying the avowal may be to our minds, in the case before us all this analogy, which is sometimes found so useful, and even the evidence of our senses, which is generally unanswerable, only served to lead us wrong; and if the microscope had not been discovered and brought to our assistance, we should still have stoutly maintained, with our ancestors, that insects, like other animals, were furnished with a pair of eyes.

But these two eyes are no sooner magnified, even with a very feeble lens, than their surface becomes so rough and unequal that they have no longer the appearance of eyes at all; and by employing lenses of greater power, the whole superficies appears covered with little round polished eminences, arranged in regular rows and at equal distances from each other. Finding that the existence of this granular surface at once precludes the possibility of supposing the two great convex organs to be single eyes, it remains to inquire what are the uses of the individual eminences or facets into which it is resolvable by the microscope, and which are so astonishingly numerous. The supposition that every one of them is a distinct eye, is not without its difficulties; as in this case it would seem that the insect should see the same object repeated, as in a multiplying glass, as many times as there are facets, and these being so numerous, vision would necessarily be exceedingly confused. On the other hand, supposing each facet to be a lens, as its shape when highly magnified indicates it to be, we should then have so many microscopic lenses, which from their extreme minuteness would be of a power incomparably greater than that of our best microscopes; and if they magnified objects in the same proportion, would represent a butterfly considerably larger than the largest whale, and of these the insect would see thousands at a time; or, more correctly speaking, it would see none of them completely, but would distinguish at the same time extremely minute portions of each, since every lens would only show what was exactly in its focus, for whatever was beyond that focus, even the distance of the thickness of a piece of goldbeater's skin, would be altogether confused or invisible: and of what use would eyes of this description be to creatures whose object was to perceive their companions at a distance, or discover their food afar off. It therefore becomes certain that neither the two great convex organs on each side of the head, nor yet the individual facets of which it is made up, can in themselves constitute eyes;—we are necessarily led to inquire in what way they contribute towards the formation of instruments of sight, and this can only be done by examining the internal construction of the apparatus. The individual facets of which the compound eye is composed, are all hexagonal in their shape, transparent and accurately fitted to each other by their edges; they are, moreover, convex externally, (fig. 3, *e*), and concave within, (fig. 3, *g*). In the centre of each is implanted a double convex lens (*d*),

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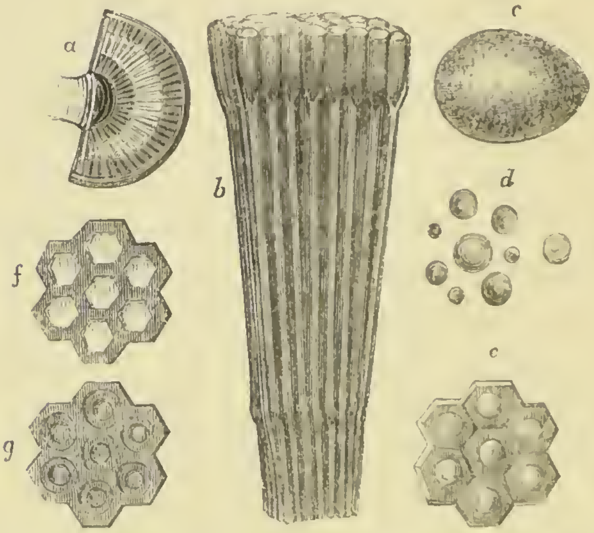
* Lyonnet, Essais anatomiques sur les Insectes, 4to. p. 440.

Fig. 3.



which from its shape must be of considerable power, and, consequently, have a very short focus. Immediately behind the hexagonal facets and their central lenses, is placed an assemblage of cylindrical bodies of a brown colour (fig. 3, *b*), so disposed that by one end each of them is fitted into the concavity of a corresponding facet. The brown appearance of these cylinders depends on the presence of a pigment of the same colour in which they are severally imbedded; its use being to absorb all straggling and useless rays of light which might otherwise cause confused vision: when the pigment is washed off, the cylinders themselves are found quite clear and transparent as the purest crystal, resembling the vitreous humour in the eyes of vertebrate animals.

To these transparent cylinders succeed an equal number of delicate filaments, which are likewise imbedded in a dark coloured pigment, and which are in fact so many of the nerves, conveying to the brain the impressions derived through the facets to which they individually belong.

Every facet must therefore be regarded as a perfectly constructed optical instrument, and the whole apparatus is consequently proved to be composed of thousands of distinct eyes. The number of facets, and consequently of distinct eyes, which enter into the composition of the wonderful apparatus we have been describing, varies in different races of insects. In the moth of the *Cossus ligniperda*, there are no fewer than 10,463 facets on each side of the head, or 20,926 distinct and perfectly constructed telescopes appropriated to the use of a single insect!

In other instances they are, of course, more or less numerous, presenting every intervening number between 50 and 30,000!

It may here, perhaps, be asked, why has such an elaborate provision of eyes been conferred for a use so ephemeral? A few days, and frequently a few hours being for the most part the limit of the insect's existence after it has assumed the perfect form, why, at least, would not a single telescope on each side of the head have been sufficient, and what can be the use of so many thousands?

To this we must answer in the words of Lyonnet himself, that that Supreme Wisdom which reveals itself in such an infinitude of ways throughout all Nature has thought proper to give such a number of eyes to the insect as is best adapted to its necessities and mode of life, and as for a thousand or two more or less, of what account can that be to the Infinite Being whose boundless power calls into existence millions of fishes from the roe of a single cod as easily as he forms the solitary offspring of the whale.

However wonderful the construction of these compound eyes may seem, made up, as they have thus been found to be, of thousands of distinct telescopes, many insects have, in addition to the complex apparatus above described, another set of eyes of a totally different construction, and which in their nature are not very remote from those furnished to the higher animals, such as fishes and reptiles. Numerous races of flies, moths, wasps, bees, dragon-flies, and many kinds of beetles have superadded to their other organs of vision two or three simple eyes or *ocelli*, which are variously situated in the front of the head. When superficially examined, the ocelli in question seem to be merely minute shining dark specks, so small as to be scarcely distinguishable by unassisted vision, nevertheless a magnifying glass soon reveals their real nature, and the patient researches of modern anatomists have even succeeded in distinguishing in them all the parts which form a perfect eye, and even in detecting the arrangement of the lenses placed within.

Having now exhausted the catalogue of the senses with which we ourselves are gifted, and found that insects seem to possess them all in a more or less efficient degree, it remains for us to inquire whether these singularly privileged beings do not enjoy modes of intercourse with the external world, of the nature of which we are of necessity totally ignorant, seeing that we have no corresponding sensations wherewith to compare them. What mysterious guide, for example, enables the bee, after having made an excursion to a distance of five and twenty miles from her hive, to wing her way back again through that trackless distance to the abode of her kindred, and that without manifesting the slightest doubt or hesitation as to which is the direct and shortest course? Not more straight or more swift is the flight of the Indian's arrow than that of the belated insect, and less unerring is the aim which launches the former towards the mark than the sense which steers the insect-wanderer to her distant home.

Can insects talk? This may indeed seem a strange question to those who would limit the meaning of the word to the capability of expressing ideas by means of articulate sounds, nevertheless a little reflection will convince any one who is conversant with the habits of these creatures, that though they may have no tongues, they can express themselves in some way or other "with most miraculous organ." Various experiments might be quoted in proof of this assertion, let us however select one or two which seem to leave no room for dispute about the matter. Any one who finds himself in the vicinity of an ant's nest, may soon be convinced that these industrious little labourers are by no means destitute of the power of communicating information to each other relative to the affairs of their commonwealth. Let him, for example, place a heap of food in the neighbourhood of the ant-hill, and watch the proceedings of its inmates. A short time will, probably, elapse before the discovery of the treasure, but at length some wanderer, in his morning's ramble, has the good fortune to stumble upon it. What does he do? He does not, like an isolated individual incapable of asking for assistance, begin at once the task of reremoving the heap, but on the contrary, off he scampers with the glad intelligence, and running his head against that of every ant he meets, manages in some mysterious way, not only to intimate the fact of the discovery, but also to give information relative to the locality where the provisions may be found, for speedily it will be seen that troops of porters, summoned at the call of the first finder, hasten to the spot, and all is activity and bustle until the store is safely warehoused in the ant-hill.

Another still more striking instance of the possession of a capability of spreading intelligence, and that of a somewhat abstruse character, is furnished by experiments that have been made by Huber and others upon bees. Every one is aware that the queen-bee is an object of the greatest solicitude and attention to all the workers of the hive, and yet, among so many thousands, all busily employed in different and distant parts of the colony, it would appear impossible for them to ascertain, at least before the lapse of a considerable time, whether she was absent from among them or not. In order to see whether bees had any power of conveying news of this kind, the queen-bee has been stealthily and quietly abstracted from the hive; but here, as elsewhere, ill news was found to fly apace. For some half-hour or so, the loss seemed not to have been ascertained, but the progressively increasing buzz of agitation gradually announced the growing alarm, until shortly the whole hive was in an uproar, and all its busy occupants were seen pouring forth their legions in search of their lost monarch, or eager to avenge with their stings the insult offered to their sovereign. On restoring the captured queen to her subjects, with equal secrecy, the tumult speedily subsided, and the ordinary business of the community was resumed, as before the occurrence.

That in such cases as those above narrated, information, and that of rather a complex character, was transmitted by one insect to another, cannot be doubted,—but by what means? All that has been ascertained upon this point is, that the ants and the bees cross their antennæ in a peculiar manner with the antennæ of the others that they encounter, and this action being repeated again and again seems to be a mode of communicating intelligence common amongst the insect races.

We will not here anticipate numerous other facts which the reader will find recorded in subsequent pages of this volume, the tendency of which will be to show our inability to appreciate the faculties bestowed upon particular tribes of insects, or even to speculate concerning their nature.

CHAPTER II.

ON THE ORGANIZATION OF INSECTS.

In the last chapter we took a brief survey of the almost incredible attributes conferred upon the insect races, the swiftest of the winged messengers employed by Nature for the execution of her high behests; our next endeavour must be to give some account of their organization and internal economy, so as to render intelligible various phenomena, which without such preliminary knowledge it would not be easy to explain. In so doing, it is by no means our intention to enter minutely into anatomical details, but simply to put the non-scientific reader in possession of the meaning of various terms which will unavoidably be of frequent occurrence as we proceed with the history of these wonderful creatures. The external skeleton, or framework, of an insect's body is composed of a peculiar substance, nearly resembling horn in its general properties; the texture of which is, however, very variable in different races, and even in different parts of the body of the same insect. Thus, in the beetle tribes, this outer case is of a very dense consistence and of great strength, whilst in other instances, where there is no occasion for so firm a suit of armour, the outer covering remains soft and flexible, resembling a kind of leathery integument; or the head and thorax may be formed of hard and solid plates, while the abdominal segments remain comparatively leather-like and yielding. In its structure this horny covering resembles very closely the skin of the higher animals, and may be described as consisting of three layers, each of which it will be important to notice. The external layer, called the epidermis or cuticle, is easily separable by maceration in water from the subjacent ones, and when thus removed it presents itself as a smooth, shining, horny envelope, closely moulded to the external form of the parts which it covers. It is generally transparent and colourless, without any traces of texture.

Beneath this transparent layer is a stratum of softer consistence (*rete mucosum*), which lines the former, and to which it is closely attached. It is upon the presence of this second layer that the colour of the insect depends for its hues, which are frequently exceedingly brilliant; and being visible through the transparent epidermis, impart all the varied dyes that diversify the members of the insect world.

Beneath the coloured and often gorgeously decorated *rete mucosum*, is the third and thickest layer of the integument called by anatomists the *corium*, or *true skin*, easily distinguishable by its want of colour and peculiar structure. This *corium*, which is the living part of the integument, consists of a web of crossing fibres, intermingled with which are nutritive vessels that supply the whole skin with nourishment, and minister to the development of the external skeleton as long as its growth is permitted. Various appendages to the integument, either useful or ornamental, are very generally met with; these present themselves in the shape of spines, hairs, and scales, distributed over the surface of the body, all of which are closely comparable in their nature to the nails, feathers, horns, hairs, &c. found amongst vertebrate animals.

The large horn-like protuberances that project from the heads or backs of some beetles, are enormously developed elevations of the entire integument, as may be easily proved by cutting them off near their base; but the hairs or scales for the two, differ only in shape, grow like the hairs of the higher animals from little roots or bulbs implanted in the substance of the *corium*, or true skin, from which they are prolonged through pores in the epidermis, and thus appear externally.

Their shape is various, generally they are simple cylinders slightly dilated in the middle and tapering towards each extremity; sometimes they are branched or divided after the manner of certain feathers, or they may be flattened out into plates of various forms, such as are met with upon the wings of butterflies and moths.

Such being the general composition of the external skeleton of an insect, we may next proceed to examine more at length the mechanical arrangement of its different parts, a subject, the consideration of which is calculated to awaken the admiration of every thinking mind, especially when it is remembered, that although our illustrations must necessarily be drawn from species of comparatively large dimensions, machinery as complicated might be found, did our powers suffice, in the minutest gnat, which, almost literally, "no eye can see," as in those races, which from their greater size, obtrude themselves upon our every-day notice.

The *head* of an insect may be considered as a horny case, or frame-work, constructed for the lodgement of the principal organs of sensation, the eyes and antennæ, and for the support of the apparatus employed in procuring food, or, in other words, of the different parts composing the mouth.

A moment's reflection upon the infinite diversity of the materials devoured by insects, will immediately show the necessity for corresponding differences in the construction of the mouth in each race of these little beings, adapting them to procure the kind of nutriment appointed for their subsistence. Some tribes, carnivorous in their habits, the tigers of the insect world, armed with teeth and lacerating fangs, live a life of rapine and slaughter, whilst others of less ferocious habits, content themselves with more ignoble fare, and, like the vultures among the feathered tribes, prey upon the carrion they are appointed to remove. By far the greater proportion, however, derive their nourishment from vegetable substances, and almost every kind of plant would seem to furnish materials peculiarly appropriated to the consumption of a particular species. Nay, even the different parts of the same vegetable are apportioned out to numerous devourers of diverse tastes and habits, all of which receive their due share of the banquet it affords.

The roots, the bark, the alburnum, the wood, the pith, the leaves, the tender twigs, the buds, the flowers, the sap, the nectar, and even the fruits and seeds, are all separately attacked by persevering bands of marauders, every one of which has a mouth adapted to the nature of its destined food.

With such infinite variety before us, it might seem a task of no little difficulty to determine where to begin so extensive a subject, but here, as elsewhere, we find,—

> "The universal cause,
> Acts not by partial but by general laws;"

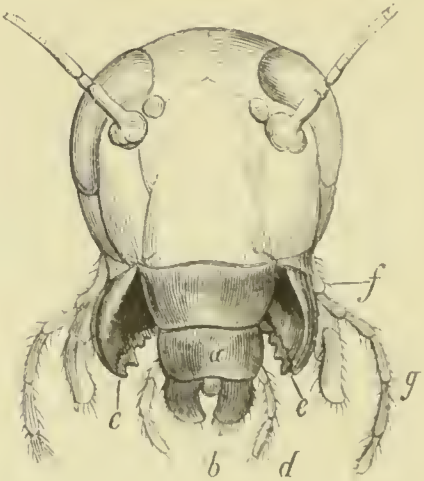
and when those laws are once understood, all that at first appeared chaotic and unintelligible, is reducible to order, and becomes capable of easy explanation.

The mouths of all insects have been proved to be constructed of corresponding parts, which being modified in their shape and dimensions, give rise by their disposition to all the varieties met with in the insect world, and become converted to the most opposite uses. Thus, the jaws of the stag-beetle, the trunk of the bee, the proboscis of the fly, the lancets of the flea, and the pump of the butterfly, are all made up of parts to which corresponding names are rigidly applicable, notwithstanding the dissimilarity of the structures themselves.

In all insects that bite or cut their food, whether they be carnivorous or live upon vegetable substances, the mouth is composed of an upper lip (*labrum*), and of a lower lip (*labium*), between which are situated two pairs of jaws, disposed horizontally, to which the names *mandibles* and *maxillæ* have been respectively applied.

The *labrum* or upper lip (fig. 4, *a*) is a narrow horny flap, which shuts down like the lid of a box when the mouth is closed, overlapping, to a greater or less extent, the subjacent pieces.

Fig. 4.



The *labium* or under lip closes the mouth inferiorly; it consists of two divisions, the *mentum* or chin, which forms the lower covering of the mouth, and the *ligula*, *lingua*, or tongue, which is of a membranaceous or fleshy texture. On each side of the tongue is a little jointed feeler or *palpus* (*palpi labiales*, *d*). These, most probably are instruments of sensation, used for the purpose of examining food taken into the mouth.

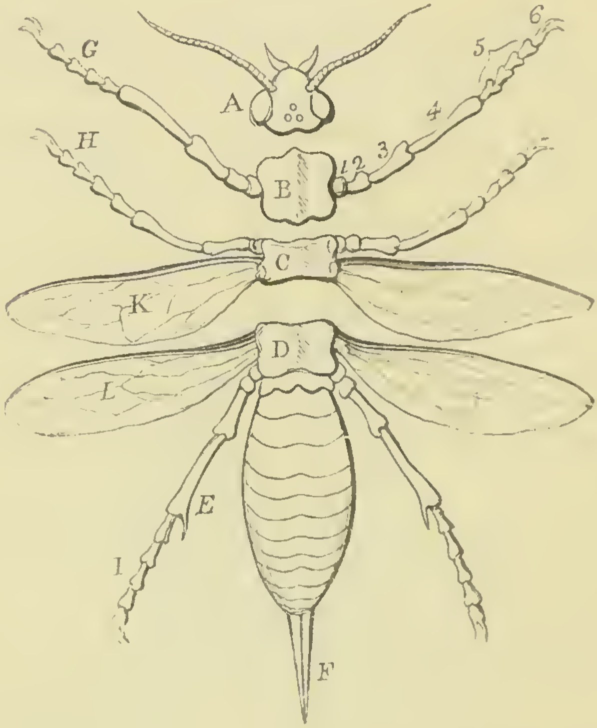
The *mandibles* (fig. 4, *e e*,) are two strong horny jaws, stoutly articulated to the sides of the mouth by strong hinge joints, upon which they move against each other in a transverse direction, like the blades of a pair of shears. These mandibles are worked by muscles of great power, and such is their strength that they easily divide the most refractory animal or vegetable substances. Their opposed edges are variously armed, so that in their functions at least they may be compared to the teeth of the higher animals, presenting prominences either in the shape of pointed fangs, sharp cutting edges, or broad grinding surfaces, according to the nature of the food to be devoured,—in fact, by the slightest modifications in their shape and armature, these mandibles serve for knives, scissors, augers, files, saws, shovels, trowels, pincers, and a multitude of other tools, according to the exigences of the insect possessing them.

Immediately beneath the mandibles is the second pair of jaws or *maxillæ* (fig. 4, *f*), which would seem to act the part of hands in supplying food to the stronger mandibles, although, perhaps, they may likewise to a certain extent assist in mastication. Each maxilla consists of four distinct pieces, and is moreover furnished with a palpus or feeler (*g*), organized like those of the under-lip, and doubtless constituting a sensitive apparatus of similar character.

The *thorax* of an insect combines in its construction extreme strength with such lightness as is indispensable in animals capable of flight.

This part of the tegumentary skeleton it will be sufficient for our present purpose to regard as consisting of three divisions, distinguished in entomological language by the names of *prothorax, mesothorax*, and *metathorax*, or named in plain English, the *front thorax*, the *middle thorax*, and the *hinder thorax*, each of which supports appropriate locomotive limbs. The prothorax (fig. 5, B) sustains the first pair of legs; to the mesothorax (C) are appended the second pair of legs, and also the anterior pair of wings, whilst the metathorax (D)

Fig. 5.



in four-winged insects has likewise a pair of wings, as well as the hind legs, attached to it.

The structure of the legs is highly curious, and in accordance with the innumerable offices to which these limbs are appropriated, in different races the modifications in their shape and armature are infinitely diversified. Each leg consists of a succession of horny cylinders, connected to each other by joints, which allow of different kinds of motion, and enclosing the muscular apparatus, whereby the movements of the limb are effected.

The first segment of the leg, usually called the *hip* (*coxa*) (fig. 5, B 1), is a short piece connected by a kind of ball and socket-joint with the division of the thorax to which it belongs.

The second piece or *trochanter* (2) likewise enjoys considerable freedom of motion, being connected with the preceding by a tough membrane, which very frequently encloses a ball-joint fitted into a corresponding socket.

The third portion, called the *thigh* or *femur* (fig. 5, B 3,) is the largest and most robust segment of the limb. It is firmly united above to the trochanter, which serves as a fulcrum upon which its movements are performed.

The fourth part (fig. 5, B 4,) is named the *shin* or *shank* (*tibia*). This is connected to the thigh by a beautifully constructed hinge, which permits of flexion and extension in one direction only.

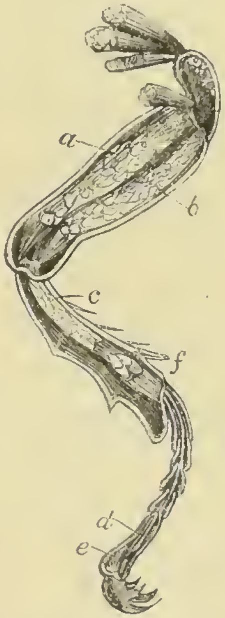
To the end of the tibia is attached the last division of the member usually called the *foot* (*tarsus*) (5); this division, however, consists of several consecutive segments, differing more or less in size and shape, the number of which varies in different families from five to a single one.

The last joint of the tarsus (6) is generally terminated by two horny claws or hooks, whereby the insect holds fast to the object upon which it moves; to these are sometimes superadded membranous cushions called soles, or climbing cushions, or else it is furnished with broad flaps wherewith to take hold of a smooth surface. The uses of these various modifications will, however, be more fully alluded to in succeeding chapters. Our space will not permit us to do more than take a peep into the interior of an insect's leg, nevertheless, however rapid and imperfect the glance may be, it might serve to teach a lesson to the wisest, and inspire the most obtuse with astonishment. Let us therefore, for an instant, follow Strauss Durckheim in his admirable display of the structure of the leg of a cock-chaffer, and see what his inimitable dissections have revealed to us. The knee-joint is, as has been stated above, a beautiful hinge, capable like our own knee of being bent and straightened again in the same plane, but not permitting of any other motion. Nothing, therefore, can be more simple than the arrangements necessary for accomplishing these movements. Encased in the interior of the thigh are two powerful muscles, one of which (fig. 6, *b*) bends the leg, whilst its antagonist (*a*) straightens it again, the two being implanted into levers projecting from the opposite sides of the axis of motion, so as to act with greater efficiency.

The machinery for moving the tarsus and foot is still more simple. The leg or tibia encloses a mass of muscle (*c*), whence a delicate thread or tendon (*f*) is derived, which passing through all the pieces of the tarsus as far as the last, is there attached in such a manner, that the contraction of the muscle *c*, aided by a little auxiliary slip, *d*, brings the foot firmly downwards, and fixes the hooks at its extremity to the surface upon which the insect walks.

To unloose the hold thus taken there is a little muscle (*e*) provided, situated in the penultimate tarsal segment, which by bending the last piece of the foot backwards serves in its turn to disengage the hooks from their hold, and thus completes the muscular apparatus of the limb.

Fig. 6.



To delineate the parts we have been just describing, even upon the enlarged scale on which they are represented in the appended figure, must have required much patient labour on the part of the artist; to display them in the leg of the cock-chaffer must have been a task which nothing short of the unwearied perseverance of a Strauss Durckheim could ever have accomplished, and we cannot but admire the penetration of his acute research, which has so far succeeded. How much must our admiration be increased when we reflect, that in the limbs of the smallest fly there exists a mechanism equally elaborate. It is only by thus closely criticising the works of Nature that their wonders reveal themselves to the mind of the inquirer; every child has seen a fly walk, a grass-hopper leap, or a daddy-long-legs employing its lengthy and thread-like stilts, yet how few consider how complete must be the enginery, and how exquisite the workmanship to accomplish these seemingly most simple actions.

The organs of flight vary much in their structure in the different orders of insects. Each wing, thin and diaphanous as it appears, consists essentially of two thin layers of a delicate transparent membrane stretched out upon an elaborately constructed framework of horny tubes, derived from the root of the wing and spreading out into numerous ramifications, so as to form a varied net-work the reticulations of which are tolerably constant in the several orders, families, and genera, and thus their arrangement becomes an important guide to the systematic entomologist.

Wings of this description generally have their surfaces smooth and shining, but frequently they are decorated with hairs of various descriptions, which, in the extensive order of Lepidoptera, are converted into flattened scales, ornamented with diverse colours.

In very numerous races of insects the anterior wings, instead of being constructed for flight, are composed of denser material, and thus converted into strong horny shields or wing-cases, called *elytra*, beneath which the hinder wings, when not in use, are concealed and protected from injury. Sometimes these elytra are partially horny and partially membranous, or they may present a dense parchment-like texture, as in the case of the common cockroaches that infest our kitchens.

In the two-winged flies, the front pair of wings alone is present, the hinder pair being represented by two little balls, called *halteres* or poisers, which must apparently be considered as rudiments of the hinder wings.

Many species of insects are entirely destitute of any rudiments of organs of flight; and by some of the earlier entomologists these were grouped together so as to constitute a special order under the name of aptera, or wingless, an arrangement than which nothing could be less natural. A little reflection will teach us that there are wingless species to be found in almost every class; and, consequently, that the possession, or non-possession of these organs is entirely referable to the peculiar habits and instincts of certain races; nay, in some cases, as for example, that of the glow-worm, one sex is apterous, while the other is provided with both wings and elytra. Admirable as is the construction of these "limber fans," the perfection of their movements is no less calculated to excite our astonishment, for even the swiftest bird is but a clumsy flyer when compared with these miracles of animal mechanism. Take the dragon-flies for an example, whose wings, formed of an inimitable net-work of horny tubes resembling the finest lace, are covered by a pure, transparent glassy membrane. "It has been observed of these insects," say Kirby and Spence, "that without turning they can fly in all directions, backwards and to the right and left, as well as forwards. This ability to fly all ways without turning, must be very useful to them when pursued by a bird. Leeuwenhoek once saw a swallow chasing an insect of this tribe, which he calls a *Mordella*, in a menagerie about a hundred feet long. The little creature flew with such astonishing velocity, to the right, to the left, and in all directions, that this bird of rapid wing and ready evolution, was unable to overtake and entrap it, the insect eluding every attempt, and being generally six feet before it. Indeed such is the power of the long wings by which the dragonflies are distinguished, and such the force of the muscles that move them, that they seem never to be wearied with flying. One species (*Anax imperator*, Leach), may be seen sailing for hours over a piece of water; sometimes to and fro, sometimes wheeling from side to side, and all the while chasing, capturing, and devouring the various insects that come athwart its course, or driving away its competitors without ever seeming tired or inclined to alight."

Equally rapid, equally exactly steered, equally unwearying is the flight of countless tribes of lesser insects.

> "Upward and downward, thwarting and convolved,
> The quivering nations sport, till tempest-winged
> Fierce winter sweeps them from the face of day."

The wing of a gnat has been calculated during its flight to vibrate three thousand times in a minute; and any one who has witnessed these little creatures sporting in the midst of a shower of rain, and skimming in and out between the falling drops, will readily appreciate the precision with which their movements are effected.

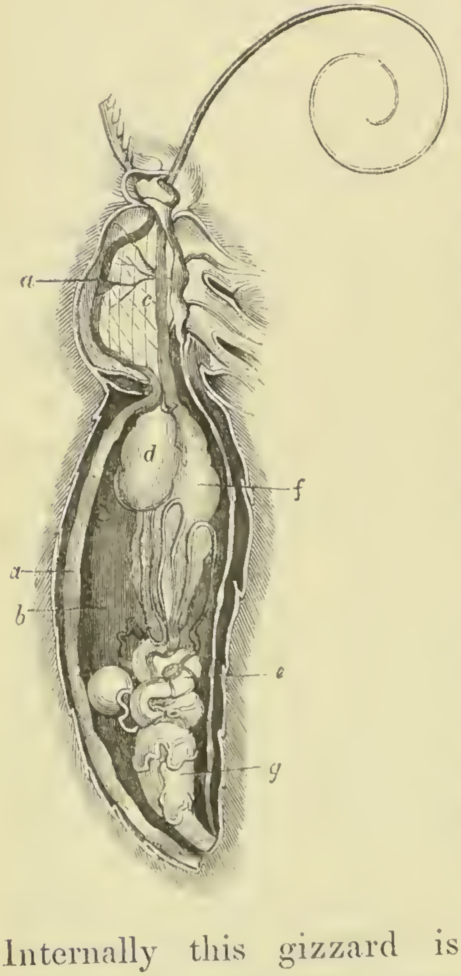
The third division of the insect's body is the *abdomen* (fig. 5, E), or that part which contains the organs of nutrition and the principal viscera. This consists of several consecutive horny segments united together at their edges by a soft intervening membrane. These segments are sometimes simple rings composed of the same dense substance as the rest of the external skeleton, but not unfrequently each segment consists of a superior and inferior half-ring, connected at the sides by soft skin, so as to permit of occasional distension, or of the movements required for respiration.

In addition to the preceding parts, the females of some races of insects are provided with peculiar appendages, used either as weapons of defence (*stings*), or as instruments for depositing their eggs in particular situations (*ovipositors*), (fig. 5, F); but of these organs we shall have a more convenient opportunity of speaking in other places.

In order to complete our general description of an insect, it yet remains to notice the arrangement of the internal organs, and point out the principal peculiarities in their structure.

The alimentary canal may be regarded as consisting of the following parts: the *esophagus*, or gullet, the *crop*, the *gizzard*, the *stomach*, and the *intestine*. The *esophagus*, (fig. 7, *c*), is a narrow tube extending through the thorax, from the mouth to the abdomen, through which the food passes in its way to the stomach. The *Crop* (fig. 7, *d*), which may be considered as analogous to that of birds, is a sack-shaped dilatation of the esophagus, the interior of which is glandular. In this bag the food is lodged when first swallowed, and herein it is prepared for the further process of digestion.

Fig. 7.



Between the crop and the true stomach of many insects is situated the *gizzard*,* a strong muscular organ, the use of which is to communicate and triturate the food. Internally this gizzard is frequently furnished with horny plates that assume the shape of knives, hooks, or grinding surfaces, according to the qualities of the materials to be acted upon.

* This organ does not exist in Lepidopterous insects, and consequently is not shown in the figure.

Next comes the stomach, properly so called (fig. 7, *f*), succeeded by the intestinal tube (*e g*) the form and extent of which is of course extremely variable in different families of insects.

We have in the preceding chapter described at some length the arrangement of the respiratory apparatus, whereby air is distributed through the ramifications of innumerable air-tubes to every part of the body; it still remains to us, however, to investigate the nature of the circulation of the blood, which is very remarkable.

The heart of an insect is a long vessel (fig. 7, *a a*), which runs along the middle of the back, and extending from the tail, is prolonged through the thorax into the head. That portion of it which is contained in the abdomen, consists of strong muscular walls, and is divided into a certain number of compartments, which communicate with each other by passages guarded with valves, so disposed as to allow fluids to pass forward towards the head, but not in the opposite direction. At the points of communication between each of these muscular compartments, there are, moreover, two wide apertures, likewise guarded by valves, through which fluids can freely pass into the dorsal vessel from the abdomen, but cannot, having once entered, escape back again through the same channel, but must necessarily, by the contractions of the heart, be forced forward from chamber to chamber, towards the anterior part of the body. The dorsal vessel, where it passes through the thorax of the insect, is not separated into chambers, but forms one continuous tube, which runs forward into the head, where it may be seen to divide into several branches, of such extreme tenuity, that all attempts to trace their precise destination have hitherto failed. Arrived at this point, the blood is supposed to find its way through various canals to every part of the body, whence it returns to the cavity of the abdomen, again to pass into the dorsal vessel, through the valve-guarded openings, for the purpose of recommencing the same course.

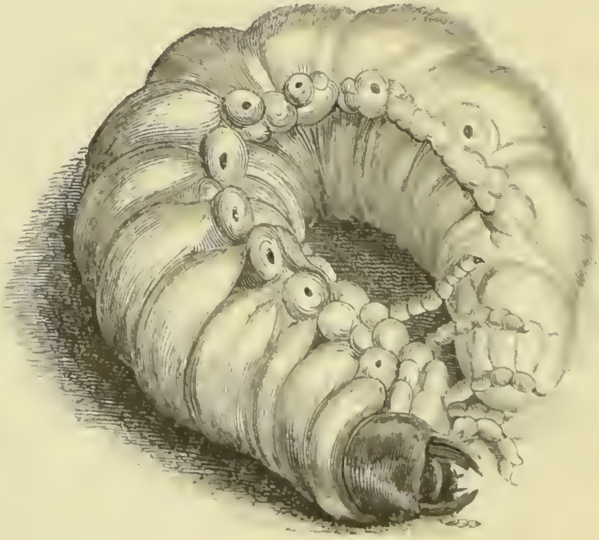
CHAPTER III.

METAMORPHOSIS OF INSECTS.

It is an extremely common, and at the same time, a very natural error, to look upon an animal as being the same creature during the whole period of its existence; neither is it without some violence to our prejudices, that we can be induced to give up a notion so long established in the mind, and yet no dogma was ever laid down so contrary to every-day experience. A slight reflection upon the subject will be sufficient to teach us that all animals in the course of their lives pass through a succession of changes both in their form, their structure, and their habits, of so decided a character, that it would be impossible, were it not proved by experience, to believe that they were not distinct and different beings. In no creatures, however, is the extent of this conversion so conspicuous, as in the class we are now considering. The insect on its first entrance into active life, so far from possessing the wonderful attributes subsequently to be bestowed upon it, and which we have described it as possessing when arrived at its adult state, is frequently inferior in its organization to some of the humblest annelidans, which, indeed, in many respects it closely resembles, and it is only by a slow and gradual process of development, that the limbs, senses, and appetites, of the insect, become ultimately matured. So completely, indeed, is the entire construction of the animal altered, that unless taught by observation, no one could possibly predicate the nature of the changes it is destined to undergo.

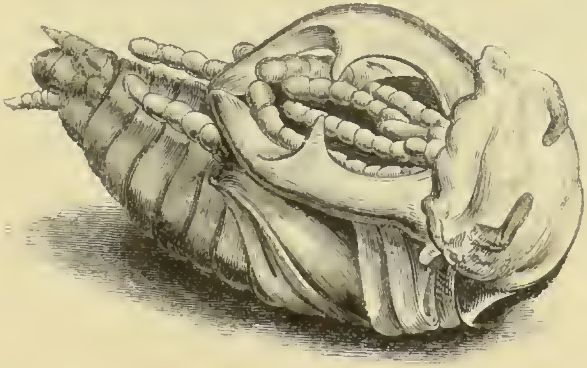
Who, for example, could expect that the unwieldly grub represented in the annexed figure (fig. 8), had any relationship with the active insect, whose powers of flight, and almost supernatural faculties we discussed in the first chapter? This creature, is found in old trees, the wood of which it greedily devours; its body is long, thick, and fleshy, and so unwieldy and inactive, that it must perforce lie constantly upon its side, curled up as here represented, for the six feeble legs appended

Fig. 8.



to the first three segments of its body, the only locomotive limbs it possesses, are evidently insufficient, even to drag its bulk along. The head, however, is strong and horny, and the mouth being furnished with sharp scissor-like jaws, is well adapted to bite and gnaw the wood, upon which it feeds voraciously. In this condition, the animal lives for five or six years, exhibiting no trace of energy further than is sufficient to enable it to cram its sluggish body with the chips that it devours, but at the end of this period, it suddenly changes its habits; instead of eating the morsels of wood, which it bites off, it proceeds to use them for building a case or coffin, in which it fastens itself up, and thus closes the first period of its existence.

Fig. 9.



Whilst thus enshrouded in a tomb of its own contrivance, it is, however, only preparing for a new and more active state of being, and should any one have the curiosity to peep into its sarcophagus, he will find the occupant not only buried, but converted into a sort of mummy of its future self, for through its swathing bands the limbs of a strange monster are all distinctly indicated, although, as yet, carefully enclosed in separate cases, accurately moulded to their shape, and folded neatly together upon the front and sides of the body (fig. 9).

In this state of seclusion the helpless creature remains until its change is completed and its newly formed members have attained their full development, when bursting the coverings which encased it, the full grown insect struggles to free itself from the vestments of the tomb, and succeeds in accomplishing its deliverance from its mummy-case: still, however, much remains to be done before it is thoroughly free. It has yet to escape from the wooden case in which it was enclosed, and afterwards to force its way out of the solid tree that formerly afforded it sustenance, a work of no little labour and difficulty; nevertheless, aided by its newly given powerful jaws, solid armour, and prodigious strength, it at last accomplishes its arduous task, and succeeds in escaping from the wooden caverns in which it had so long been a resident, to enter upon a new sphere of existence, under the shape of the winged beetle (*Lucanus cervus*), represented in the woodcut (fig. 10). Linnæus, always remarkable for a felicitous selection of the terms he employed, believing the grub or caterpillar to be merely the perfect insect concealed by a disguise, that hid its future form from observation, named it in its first state of existence, a *larva*, the word by which the ancients designated the masks employed in their scenic representations, and which, when cast off, exhibited the real actor in his proper figure. To the second phasis of its life, in which it is found swathed up as it were, in swaddling bands, having much the same appearance as the infants, which are yet so treated in many European countries, he applied the designation of *pupa*, a baby,—while to

Fig. 10.

its last or adult state, he gave the name of *imago*, as being really the representative of the race.*

Let us, however, take another example of these surprising changes, preparatory to examining their real nature and the mode of their accomplishment.

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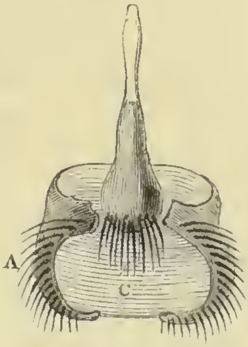
* It may here be well to remark, that in the following pages, the terms *larva, grub, caterpillar,* and *maggot,* will be applied indiscriminately to the first state of the insect ; *pupa* and *chrysalis* will equally denote the second ; while the expressions *imago, fly, perfect insect,* or the generic name of the individual spoken of, indicate the third or mature condition.

The butterfly, on escaping from the egg, presents itself under a form widely different from that of its parent, and equally dissimilar from that which it will itself exhibit at a subsequent period of its existence. Its body is elongated and worm-like in form, consisting of thirteen segments, inclusive of the head; and this number of segments appears to be general in larvæ of all descriptions. The head contains the instruments of the senses, and the apparatus of the mouth; while to other parts of the body limbs of various kinds are appended. Of these a pair is situated upon each of the three anterior segments immediately succeeding to the head, which segments are destined subsequently to form the thorax of the butterfly; consequently these six anterior feet must be regarded as the representatives of the future legs of the perfect insect. Their structure, however, is widely different from that which these organs will afterwards exhibit, inasmuch as they are as yet very short and stunted, and being terminated by strong horny hooks, seem but rude and clumsy organs of progression.

The other legs, situated behind these, are called abdominal, or false legs, and are of very curious and admirable structure. In the Caterpillar of *Cossus*, the great goat-moth, examined by Lyonnet with such laborious minuteness, each short leg forms a short fleshy cylinder terminated by a flat sole, or foot, of very remarkable organization. The margin of this circular foot is surrounded by several rows of sharp curved hooks, having their points directed outwards, while the fleshy disk, or sole, being gathered into puckers towards its centre, can be drawn in and rendered concave at the will of the caterpillar. It is evident from this arrangement that when these feet are applied to any object, the circle of hooklets will attach itself to the surface upon which the caterpillar walks, and that by their contracting the sole of the foot, they may be readily made to relinquish their hold preparatory to taking another step forwards. In the caterpillars of the hawk-moths which have obtained the generic name of *Sphinx*, in consequence of the remarkable attitude that they ordinarily assume, the structure of the abdominal legs is different, but equally curious; each foot is in these larvæ divided into two parts, the outer division being edged with minute hooks, turned inwards like a claw, while the internal half is likewise furnished with hooks, directed outwards: so that the two parts of the foot are opposed to each other and grasp the surface upon which the creature walks, somewhat in the same way as the foot of a bird embraces the branch of a tree. The number and position of the abdominal feet varies considerably in different tribes of Lepidopterous larvæ. Sometimes there is only a single pair attached to the hindmost segment of the body, whilst in other

Fig. 11.



instances six, eight, or ten pairs are met with, situated upon the sixth, seventh, eighth, and ninth segments; but none are ever found on the fourth, fifth, tenth, or eleventh segments.

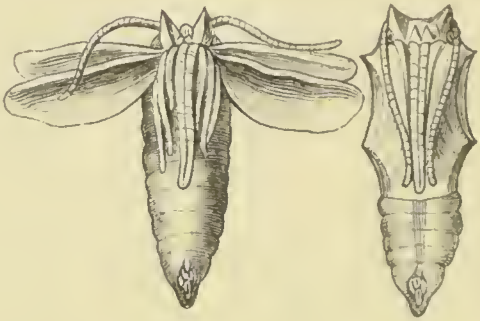
The head of a lepidopterous larva is generally furnished with eyes, but these are of a very simple and rudimentary character when compared with the organs of vision that are subsequently bestowed upon the adult insect; they consist of six very minute specks, visible on each side of the face, and occupying the usual situation. The only representatives of the antennæ which are hereafter to become important instruments of sensation, as yet to be detected, are the little conical appendages situated just above the mouth, each of which consists of three small joints; these, in some instances, are capable of being drawn into each other like the tube of a telescope. The mouth of a caterpillar is a very efficient piece of mechanism, and admirably adapted to satisfy the cravings of its voracious appetite; it consists of an upper and under lip and of two pairs of strong horny jaws, which move horizontally, acting against each other like the blades of a pair of scissors, so as to cut, with wonderful facility, the leaves or other substances devoured for food. But besides the organs above mentioned, the head presents another apparatus, only existing during the larva condition of the insect, wherewith the little creature is enabled to construct for itself a silken thread, of great importance in its own economy, and which the ingenuity of mankind has succeeded in employing for various purposes.

It would seem that the principal business of the caterpillar is to *grow*, and in order that its growth may be accomplished as speedily as possible, its voracity is proverbially insatiable; and where multitudes of them happen to be congregated together, the injury they are capable of inflicting upon the agriculturist is terrible. From careful experiments made by Count Dandolo upon the growth of the silkworm, it appears that during the very short period of the existence of that insect in its larva state, it increases to nine thousand five hundred times its original weight.

To allow of this vast and astonishingly rapid increase of size, the larva is under the necessity of frequently changing its skin, throwing off, at stated intervals of time, its old covering as it becomes too small, and appearing again and again in a new great-coat, better adapted to its progressively increasing size. This process of changing its external tegument, or moulting, as it is technically called, is repeated four, five, or six, or in some instances as many as eight or ten times during the caterpillar state of the insect, at the conclusion of which its size is far greater than at any other period of its life.

Having thus completed its growth under the appearance of a caterpillar, the insect remains for a short time in a state of inactivity until everything is ready for throwing off its last larva investment; on removing which it presents itself under the shape of a chrysalis. After casting its last caterpillar covering, the denuded insect still remains quite soft, and by care it is not difficult to detect, in a rudimentary state, the wings and other appendages of the butterfly, which for a few hours lie loose, enveloped in their delicate sheaths upon the surface of the body. This condition is, however, of very brief duration, for in the course of a short time a thick viscid gum-like fluid exudes from the exterior of the chrysalis, chiefly poured out from beneath the nascent wings, which spreading over the body like a coat of varnish, soon hardens into a horny case, and glues together the legs, wings, antennæ, and all the rest of the creature in one common investment, which in time acquires a golden or rich brown tint as the varnish becomes gradually rigid and opaque.

Fig. 12.

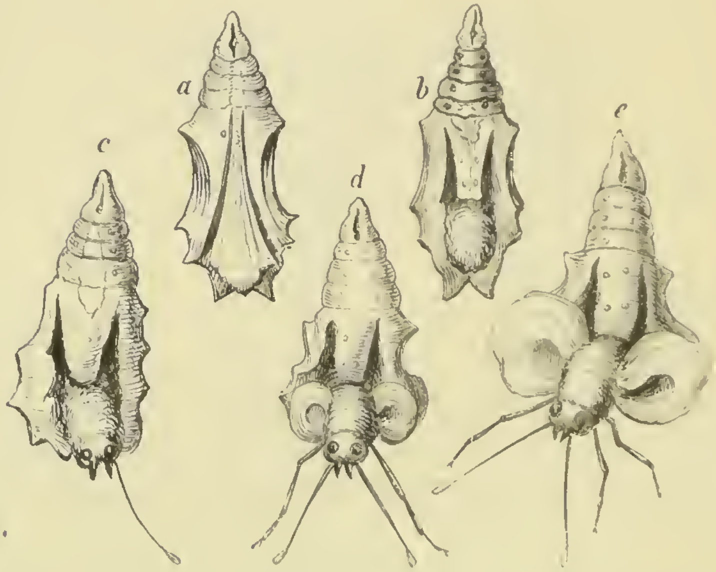


Beneath the chrysalis case, thus composed of hardened varnish, it is still possible to trace the subjacent limbs of the future butterfly, neatly packed up and closely applied to the surface of the body, in which condition they remain until sufficiently matured to allow the last scene of this strange metamorphosis to be accomplished.

The length of time passed in the chrysalis condition is very variable in different species. Some require only two or three days for their maturation, whilst others demand as many weeks or months, or even years for the completion of the included insect. Moreover, it has been ascertained that even chrysalises derived from the same brood, are by no means necessarily hatched simultaneously. Their development goes on until at last they attain their complete state and are ready to be called into active exertion.

The development of its limbs being accomplished, the imprisoned butterfly only awaits the occurrence of favourable circumstances to break loose from its confinement. The time arrives—and struggling to get free, the little prisoner by a few vigorous efforts bursts its horn-like covering and soon succeeds in rending a wide opening, through which it proceeds to extricate itself from its mummy-case, gradually drawing its limbs, antennæ, proboscis, &c., out of the different sheaths in which they had been separately folded. Having accomplished this, the perfect insect or imago is revealed to view. At first it appears in a very weak and languid condition. Its body is still soft and covered with moisture, and its wings are wet, crumpled, and flaccid, of a dull muddy colour and quite devoid of those bright hues and elegant markings which are soon to become so conspicuous. A very short time, however, is sufficient to clothe it in all the splendid livery of its species. The moisture of its skin becomes dissipated, and its wings expand by degrees to four or five times their original dimensions, displaying as they become developed, with gradually increasing brightness, their various colours, the butterfly appears arrayed in all its transcendent beauty.

Fig. 13.



It is by no means easy, at first, to comprehend how this rapid expansion of the wing is effected, and how in the course of half an hour such a wonderful display of gorgeous colours should be produced, which previously seemed to have no existence. The explanation, however, is extremely simple. The wing of a butterfly, and indeed of all other insects, as before stated, consists of two membranes, one forming its upper, the other its under surface. These membranes, although continuous around the margin of the wing, are not, at first, adherent by any part of their contiguous surfaces, so that they form a kind of bag, as may easily be proved by soaking the wing of a newly escaped butterfly in weak spirit of wine, which becoming absorbed separates the two membranes of the wing, between which is interposed a framework of horny tubes, or *nervures*, as they are technically termed, and also numerous vessels for the conveyance of air and other fluids; these, when the wing is first extricated from the pupa-case, are empty and collapsed, so that the outer membranes are crumpled up upon them in numerous transverse and longitudinal folds. One of the first acts, however, of the newly evolved insect is, by the contraction of its body forcibly to distend this framework of tubes, which becoming expanded spreads out in all directions, at the same time stretching the two membranes between which it is enclosed, so as to obliterate all the folds and creases that previously existed, the wing thus soon attains its full expansion, and the membranes of the opposite sides now brought into close contact become permanently adherent together.

The development and gradual arrangement of the colours is equally explicable from the same conditions. The wing of the butterfly and of all Lepidopterous insects, is covered with variously coloured imbricated scales that overlap each other like the tiles of a house. These in the collapsed condition of the wing are so crowded together, that their arrangement is not to be seen. But when by the expansion of the wing they are arranged in their proper situations, each ocellus and spot takes its destined place, and every ornament becomes displayed, just as a fan unfolded reveals the picture painted upon it, which previously was quite undistinguishable.

Wonderful as are the changes thus accomplished in the external appearance of the insect, they are by no means the most surprising that are in progress during the transition of the insect from its caterpillar to its imago condition. A metamorphosis equally miraculous is simultaneously going on in every part of its internal economy, whereby the whole animal becomes adapted to a new sphere of existence. All the complicated machinery of the muscular system appointed for the various movements of the different limbs and external appendages must necessarily be entirely remodelled and renewed in proportion as those limbs become changed in their structure and appropriated to other uses.

With the disappearance of the false legs, which in the caterpillar formed such an important part of the locomotive apparatus, the numerous muscles that gave them motion are entirely obliterated, while on the contrary the muscular mechanism belonging to the anterior legs, which in the caterpillar were mere inflexible horny claws, are in the imago state of the insect arranged to move all the different joints which now enter into the composition of those members, and become capable of a delicacy of action that was not required in their preceding condition. The wings, whereof not a rudiment could be detected in the caterpillar state, are wielded by elaborately arranged muscular masses, derived from a solid internal frame-work specially constructed for their lodgment, and the formation of which necessarily must have kept pace with the development of the wings themselves. In the same manner the muscles of the antennæ, of the different parts of the mouth, and of every other moveable portion of the insect, are all newly constructed or rearranged in conformity with the external changes that are in progress. The capacious stomach of the voracious leaf-eating caterpillar shrinks into dimensions adapting it to be filled with honeyed fluids; the organs of circulation and respiration undergo changes commensurate with the rest of this metamorphosis; the organs of sense are completely remodelled; the stunted feelers of the larva are converted into long and complex antennæ; the six simple specks or ocelli, which in the first stage of the insect's life were the only instruments of vision, are replaced by compound eyes made up of several thousand facets; the silk-secreting apparatus entirely disappears during the chrysalis condition, whilst the reproductive system, scarce a rudiment of which could be detected in the caterpillar, assumes its complete development, and the insect is enabled to lay its eggs as the last act of its existence.

We have, however, yet to consider what is the real nature of the phenomena above described, which must at first sight appear so mysterious and inexplicable, and which have in all ages afforded a fertile theme for speculation and conjecture. The ancient philosophers, utterly at a loss to frame any probable hypothesis upon the subject, were content to merge all inquiry concerning it in visionary speculation or mythological allegory, and even in modern times the ideas of writers of high eminence have been upon this topic strangely confused and unsatisfactory.

The most favourite theory up to within the last few years was, that the young caterpillar at its escape from the egg was already provided with all its future skins ready formed one beneath the other, and that the most external being cast off at certain intervals, that immediately underneath it became revealed to view, until all the larva coats being exhausted we came at length to the pupa-case, and this being thrown off in its turn, the animal itself became displayed in its true form. Certainly the advocates of this strange doctrine could scarcely have reflected upon the real object of so many changes of skin, namely, to provide a succession of larger coverings proportioned to the continually increasing bulk of the larva.

Nothing in fact can be more simple and free from the miraculous than the entire process.* At certain periods, when the old cuticle becomes too small for the rapidly enlarging dimensions of the insect, it is gradually loosened, and at length separated from the living skin or cutis by which it was originally secreted, and a new exudation of horny matter taking place from the whole surface of the caterpillar, a fresh and more extensive layer of cuticle is slowly formed, and then, the old, dry and dead epidermis being quite detached is split by the exertions of the larva, and the newly secreted layer placed beneath it appears. The old skin is at length completely thrown off and the newly formed one soon hardening by exposure, the reclothed caterpillar again assumes its former activity and habits.

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* See the Author's "General Outline of the Animal Kingdom," p. 299.

Neither is the change from the larva to the chrysalis less easily explained, although regarded by our forefathers as being so mysterious and astonishing a phenomenon. The reader will bear in mind that, whatever the form of the exterior or epidermic crust, it is merely a dead secretion, unchangeable when once deposited; but beneath this outer covering the *living integument is during the whole process of the metamorphosis* undergoing great and important changes, increasing, during the larva condition of the insect, in *size* only, without any material alteration in its general shape; but when sufficiently organized, that is, at the commencement of the pupa-state it begins to develop itself at different points, and expands into variously shaped organs, which did not previously exist, such as the wings, legs, eyes, antennæ, &c., of the perfect insect.

After having attained the pupa-state, the last steps of the process are completed, and the dermic system becomes fully developed in all its parts. The apparatus of the mouth attains its perfect condition, the wonderfully elaborate structure of the eyes is completed, the antennæ assume their full development; the legs attain their mature form, and the wings, which have been continually growing, although concealed in the wing-cases of the pupa, are ready to become expanded. The time arrives for the completion of its last change, and after a few struggles, the insect escaping from its thraldom enters upon a new state of existence, and commences its aërial career.

CHAPTER IV.

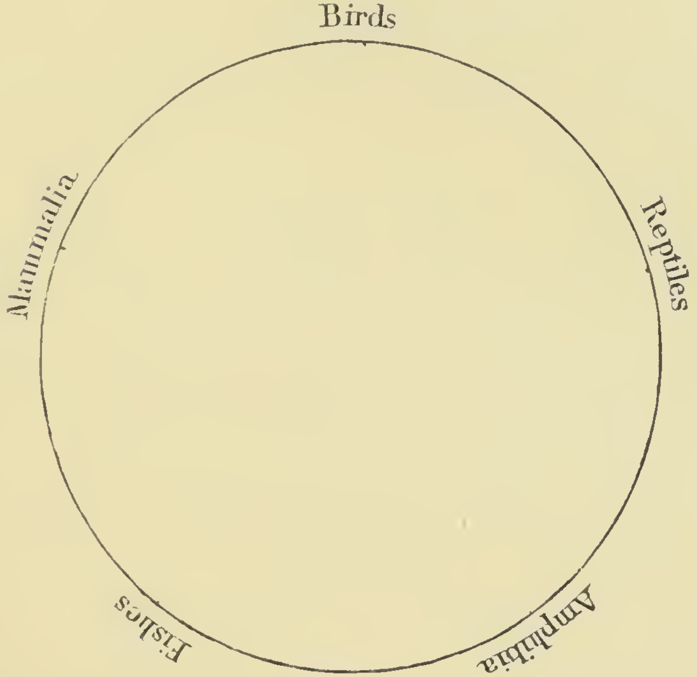
DISTRIBUTION OF INSECTS.

To a superficial observer of the animal creation, the lengthy catalogue of living organisms that share with our own race the occupancy of this globe, existing under such countless forms, and presenting so many diversities of structure, it may be pardonable to consider them as being arranged in one unbroken series—one "vast chain of being," the successive links of which may be traced continuously, either in an ascending or descending direction; but whoever begins to climb the mighty ladder, step by step, will not be long in perceiving such a supposition to be by no means tenable, as he will be obliged in his straightforward upward course, perpetually to be passing by, both on the right hand and on the left, numerous animals which cannot be made exactly to enter into the direct succession; and after some consideration he will, doubtless, be convinced that modern zoologists have done right in describing the animal kingdom as being made up of a multitude of circular groups of creatures nearly related among each other in the main features of their economy; but at different points of the circle possessing particular attributes, by which they become allied with animals belonging to several other circles.

Taking, by way of example, the vertebrate division of the animal creation, we ought,—were the hypothesis of a continuous and unbroken series to be adopted,—to be able, beginning with the lowest of that group, at once to enter upon a line of creatures progressively advanced above each other in their attributes until we are conducted by almost imperceptible steps to Man himself, the topmost pinnacle.

On endeavouring to trace this series it is, however, found to be quite impracticable. Again and again the zoologist is compelled to retrace his steps in order to collect on all hands the stragglers left behind, until at length he finds himself obliged to give up in despair his attempts to make them conform to anything like a linear arrangement. By disposing them, however, in a circular form, this otherwise insuperable difficulty is at once removed; and it is found that all the vertebrate classes may in this manner be disposed of, without violating the affinities whereby they are related to each other, as in the annexed diagram: on inspecting which it will be at once evident, that no violation of the series of Nature can occur—the mammalia are connected on the one hand with the birds, through the intervention of such creatures as the *ornithorynchus paradoxus*, and on the other with the fishes, by the interposition of seals and whales. The birds glide almost imperceptibly into the reptilia through the crocodiles, *pterodactyle*, and other reptiles of intermediate structure; while the amphibia are equally allied to the reptiles and the fishes through the frogs at one end of the series, and the eel-like syren at the other, thus completing the circular arrangement.

Fig. 14.



Thus far there can be no doubt that the framers of the circular theory are quite justified in their views, and have well deserved the thanks of the scientific world for clearly expressing a truth of primary importance in natural history; but they do not stop here, they tell us that every natural group of animals, large or small, is composed of a certain invariable number of members, all blending into each other at their confines and forming a circle. In this manner they proceed, beginning with the higher groups and descending to the lower, until at length they come down to *genera*, properly so called, and reach at last to *species*,—every group, whether large or small, forming a circle of its own. What the natural number really is, the advocates of this theory are not quite agreed upon; some say three, some five, some prefer the number seven, as being the "most scriptural number," while others contend for nine; the favourite of the present day is, however, five; and hence this theory is universally known as the "Quinary System."

It is, to say the least, difficult for the student of Nature, who has been in the habit of considering the works of the Creator in their plenitude and their vastness, to imagine that the boundless Eternal, infinite in power and uncontrollable in majesty, should have chosen, whilst framing those laws, "which but to guess a Newton made immortal," to trammel his almighty works by fixing on some mystic number for his guidance, be that number five, or seven, or nine; we could as soon imagine that the ocean wave lies down and crouches on the shore because a man has stuck his stick into the sand and bid the water not to pass it; or that the sun turns back in his career because the astronomer has drawn the imaginary line.

Simpler, and to our apprehension far more grand, must be the real law, in accordance with which the forms and the structure of all living things are planned and regulated. "The heavens above and the earth beneath, and the waters under the earth," are the three grand domains of Nature, all of which, throughout all their regions, have to be supplied with fit inhabitants, derived as far as possible from every class and grade of animal intelligence; and, of course, the range of their dominion extending as it does

> "Per mare et terras cœlumque profundum,"

requires appropriate modifications in the organization, and in the habits of the various members of each group.

Regarded in this light it is evident, that if numbers are to be at all considered in the matter, the ternary arrangement will be that of Nature; and the air, the water, and the earth will form the three cardinal points to be marked down on the circumference of the grand circle of animal existences. With these to start from, it becomes by no means difficult to fix the intermediate points, and to make five, or seven, or nine, the ruling number at the pleasure of the naturalist, just as with the three primary elements of light it is possible to procure all the tints which the solar spectrum can furnish; and were all the various localities appointed to be occupied by living creatures defined, each in its appropriate place, like the degrees into which mathematicians divide the circle, it would be as impossible to indicate one left vacant, as for the needle to point out an unnumbered space while it ranges round the compass searching for the northern star.

Thus is it with the members of the insect world; some specially appointed to the air, seem only formed for flight, and spend their lives upon the wing; others are satisfied to flit from flower to flower in search of food, while others choose the land, the marsh, the water, as their proper spheres of action, guided by the structure of their limbs and their peculiar instincts.

It is of little importance where we begin our survey of this vast and interesting class of animals, our object being rather to illustrate their importance in the general economy of Nature, than to set forth their individual histories; we shall, therefore, select the most striking examples adapted to our purpose without much reference to classical arrangement, although at the same time it will be our endeavour to lay before the reader, as completely as we may be able, the principal facts ascertained by naturalists, relative to the habits and metamorphoses of the different orders into which insects have been divided by naturalists.

Nothing is more calculated to excite the astonishment of the student of animated nature, than the strict balance which is preserved between the destruction and the reproduction of insects. Countless millions are continually making their appearance upon the stage of existence, millions equally innumerable are as constantly perishing, and yet, steady to their appointed duties, the insect races return with the seasons to which they belong, neither dangerous by their multitudes, on the one hand, nor, on the other, inadequate to perform the gigantic tasks that devolve upon them. Dreadful indeed would be the consequences, if the strict and vigilant superintendence under which insects live, were, but for a very little time, intermitted—for not a species could be pointed out, however diminutive and apparently contemptible, that might not, unless jealously restricted in its fertility, become a scourge to the rest of the living creation. The gnat and the mosquito are not, individually, very formidable objects to contemplate, nevertheless when found in their unchecked multitudes, among the neglected swamps of savage regions, even these become the tyrants of the wilderness, and man himself vainly endeavours to find a resting-place, where they have taken possession of the soil.

A locust is not, in itself, a very redoubtable foe, and were it not for dire experience of its ravages would be as little feared as the grasshopper that chirps in our meadows, nevertheless, as we are told, there is an eastern fable which says that upon the wing of the locust is an inscription to this effect—" We are the army of the Most High God; we lay ninety-nine eggs, did we lay the hundredth we should eat up the world and all that it contains;" and the language of this splendid orientalism, forcible as it is, is by no means too strong for the occasion.

But let us take a familiar illustration of our meaning. The common white butterfly, which frequents our gardens and flutters among our cabbages, would scarcely, as we suppose, excite alarm in the breasts of the most timid; and yet a little reflection will convince us that even this gentle flutterer, whose appearance is always hailed with welcome, would, if not assiduously watched over, soon become the cause of desolation and famine. The butterfly is engaged in depositing its eggs, gluing them to the cabbage-leaves on which the young caterpillars are to feed as soon as they are hatched, and, perhaps, before it quits the garden it will lay five hundred eggs, every one of which will produce a voracious larva, that if matured into a butterfly would in turn lay *its* five hundred eggs likewise, thus leaving two hundred and fifty thousand hungry caterpillars, the progeny of a single butterfly! What then would be the consequences if but a hundred of these apparently innocent insects were to lay their eggs in the same garden, and their offspring, secure from persecution, were all of them to arrive at maturity? Obviously they would eat up every green herb that could yield them sustenance, and leave want and desolation behind them.

In considering this important question there are, as the reader will perceive, two contingencies to be provided against. That the numbers of voracious caterpillars must be rigidly kept down has already been made evident; but on the other hand, be it remembered, that were the supply of caterpillars to fail, or even to be materially decreased, numerous animals which are dependent upon them for food must lack their ordinary nourishment, and perhaps perish. Here then is the great difficulty,—it is absolutely necessary that caterpillars shall be produced by thousands, and tens of thousands, as a means of feeding other creatures, and it is equally necessary that but a very small proportion of these multitudes shall ever be permitted to lay eggs. In this dilemma, we are scarcely surprised to find that a race of insects has been organized, whose sole occupation seems to be to keep within due bounds the numbers of caterpillars, and thus to save the country from such disasters as we have hinted at. These are the *Ichneumons* (fig. 15,) an extensive family of Hymenopterous insects, hundreds of which may be seen in summer time flying around every bush, or prying with persevering curiosity into every lurking place wherein the objects of their search may be secreted.

Fig. 15.

The female ichneumon is furnished with an ovipositor, or instrument wherewith to lay its eggs, by the aid of which it deposits them with remarkable expedition, in the larvæ, pupæ, or even eggs of such insects as it is taught to select for the purpose.

No sooner does an ichneumon perceive a caterpillar such as it is in quest of, than it proceeds by means of its ovipositor to drill a little hole through its skin, wherein it lays one or two or sometimes several eggs, according to the size of its victim; having accomplished this, the ichneumon flies away in search of other caterpillars, in which she plants a few more eggs.

The unconscious caterpillars go on eating and enjoying themselves, as if nothing had happened, and seem to suffer little from the operation; but the intention of Nature has been accomplished, the germs of death have been sown, and time only is wanting to complete the work.

Shortly the eggs of the ichneumon are hatched, and the young grubs that result from them immediately begin to devour the store of fat that ought to serve for the nourishment of the caterpillar during its inactive chrysalis state. No vital organ is injured by the parasitic grubs, the caterpillar lives on and ultimately becomes converted into a pupa, but here its career ends; instead of being permitted to assume the winged form and lay its five hundred eggs it perishes, as it were, on the threshold of its last state of existence, and the entomologist who expects the chrysalis to yield him a splendid specimen of a butterfly, finds, very frequently to his chagrin, that it produces nothing but a few little ichneumons, living testimonies of the fidelity with which the work of Providence has been accomplished.

The remarkable ovipositor bestowed upon the ichneumons might be compared to a sort of drill or dibble, with which the insect's eggs are sown one by one, in numbers proportionate to the richness of the living soil appointed for their reception, and having once supplied an instrument of this description we are not surprised to find it convertible by Nature to various and widely different uses. The nicely adjusted play of instincts and blindly exercised caution requisite to ensure the successful issue of the ichneumon's stratagem need hardly be insisted upon; but when we come to look a little further, we shall soon perceive that they are simple when compared with what occurs among other races of insects furnished with instruments of very similar contrivance.

The saw-flies (*Tenthredinidæ*) are equally remarkable for the manner in which the female insects provide for the safety of their eggs, which they deposit in incisions excavated in the stems or leaves of plants.

It would be difficult, in the whole range of animal mechanics, to point out an apparatus of more exquisite construction than the saw with which these little insects are furnished; nothing certainly ever manufactured by human ingenuity is at all comparable to this beautiful mechanism.

Beneath the hinder part of the abdomen of the female *tenthredo* is a long narrow slit, bounded by horny plates, between which, when not in use, the cutting machinery is securely lodged and protected from injury; but when the little insect requires its services, the saw is raised out of its sheath, so that its sharp edge may be applied to the surface she wishes to incise.

On a cursory inspection, the saw (fig. 16) would seem to consist of a single piece, but on a more attentive examination, no fewer than four plates are found to enter into its composition, namely, two saws laid side by side, with their cutting edges touching each other, and two supports very similar to the saws in shape and general appearance, which likewise touch each other by their thin edges along the opposite margin of the instrument. A deep groove runs along the thick edge of each support into which the back of the saw is so fitted that the latter can slip backwards and forwards without getting out of the groove. When these four pieces are together, they enclose a canal through which the egg of this insect can be extruded into the fissure made by the action of the saws. The cutting edge of each saw is armed with nineteen or twenty teeth, these are very small, and appear at first to be of simple structure, even when considerably magnified, but when examined with very powerful glasses, it is found, to the surprise of the observer, that every one of these teeth is itself a saw, armed with eighteen or twenty other teeth of extreme delicacy, as represented in fig. 17. Every species, moreover,

Fig. 16.

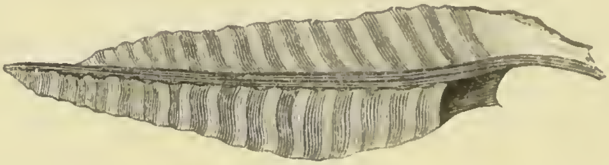
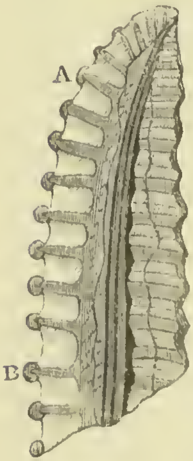
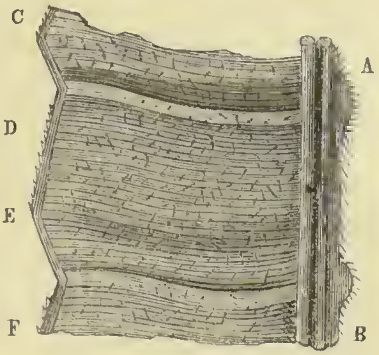


Fig. 17.



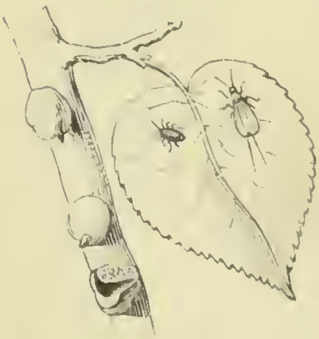
would seem to have the teeth of its saw constructed upon a principle peculiar to itself, but in all they are equally admirable. Thus, in another form examined by Lyonnet, the saw was armed with sixteen teeth, resembling flat cutting plates (fig. 18, C, D, E, F,); when further magnified, each of these teeth was found to be itself minutely serrated, forming a cutting apparatus exactly comparable to an instrument used in surgery called after the name of its inventor, Hay's saw. Besides the teeth above described, which give a cutting edge to these exquisitely constructed organs, the whole of the flat side of the saw is covered with multitudes of sharp points, so small as scarcely to be seen by the aid of the best glasses, but which constitute an extremely delicate file, wherewith the incision made by the saws can be subsequently enlarged to any required extent.

Fig. 18.



Any persons anxious to observe the proceedings of the sawflies, whilst in the act of using the beautiful apparatus above described, may easily satisfy their curiosity during the summer months, more especially as the insects are by no means easily disturbed while at their work, and may even be closely watched with magnifying glasses without exhibiting any indications of uneasiness or alarm. A rose-tree is generally most favourable for the purpose of the naturalist, on the younger shoots of which these flies may generally be met with, creeping along in search of a commodious place where their eggs may be deposited. Having selected a proper spot, the process of oviposition at once begins, and the play of the complicated saw may readily be witnessed.* In laying her eggs it is not only necessary that the female saw-fly should make a clean incision into the rose-twig, but a cavity must likewise be excavated for the reception of the egg that is to be deposited therein. If we watch how this is accomplished, the necessity for the peculiar structure of the saw will be soon evident. Our saws, whether employed to divide a piece of wood lengthways or across need not be pointed, but as they divide the surface to which they are applied they easily make an incision, or "saw-gate," which is of the same width throughout. But the incision made from the fly's saw must be of a very different kind, having its shape adapted not only to receive but to cover the egg that is to be placed within, and the mode of its formation is as follows: the tenthredo forces its ovipositor into the twig, much in the same way as a surgeon plunges his lancet into a vein, directing it perpendicularly at first, and then cutting obliquely outwards. The two saws thus infixed through the bark and woody fibre, now begin their sawing movements, and with

Fig. 19.



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* Reaumur, tom. v. mem. 3rd.

the file-like teeth disposed upon their edges and outer surfaces, soon excavate a chamber precisely fitted to receive the egg, which is immediately dropped in the incision, together with a little globule of glutinous fluid, the latter being perhaps intended to prevent the edges of the newly-made wound from growing together. Having accomplished this the insect proceeds to make another incision, at a little distance from the former, in which she lays another egg, until a dozen or two are laid in a row upon the same twig.

That part of the branch in which the eggs have been deposited, undergoes no change for the first twenty-four hours, being only distinguishable by the row of incisions, which look like so many lancet-punctures; but in a day or two the part around each cut becomes brown, or nearly black, indicating that the wounded fibres of the twig have perished and begun to dry. Another more remarkable change is soon apparent, for all the cells begin to enlarge, and in the course of a few days their situation is indicated by a row of olive-shaped elevations, placed along the branch like a string of beads; yet these gall-like excrescences must by no means be mistaken for growths from the wounded branch itself: on the contrary, their origin is entirely due to the enlargement of the eggs within, which, after they are deposited, increase in size in a very remarkable manner. These eggs are in fact enveloped in a thin membrane, very unlike the hard and brittle shell of a bird's egg, and actually grow day by day after they are deposited, so as materially to enlarge the cell which contains them; and in order to provide for this enlargement, the parent insect takes care to leave a sufficient interval between the different cells to allow them to expand without pressing upon each other. As the growth of the egg proceeds and the cell becomes more and more distended, the incision whereby the former was originally introduced, is gradually torn open, so that by the time the egg is hatched a wide passage is prepared for the exit of the larva, which thus easily escapes from its imprisonment.

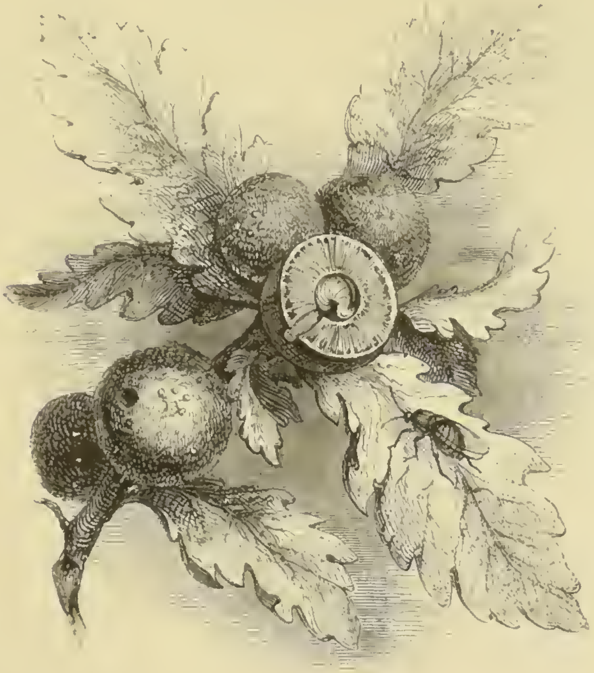
The larvæ produced from the eggs that have been thus curiously preserved, have very much the appearance of caterpillars, on which account they have been named "false caterpillars," by some entomologists. As soon as they are born they eagerly set to work to devour the leaves in their vicinity, contenting themselves at first with the softest and most delicate portions of the foliage, but afterwards, when their jaws acquire sufficient force, devouring the whole leaf with most destructive voracity. In the course of a few weeks their larva-growth is completed, and they prepare to enter the pupa state by providing means of defence to secure them during their period of helpless inactivity. The means at their disposal for this purpose are very similar to those employed by Lepidopterous larvæ, each false caterpillar being provided with silk tubes and a spinneret, wherewith to weave a cocoon, fashioned much in the same way as that of the silkworm. In order to construct this, the larvæ of many species bury themselves in the ground, where they first excavate a cavity adapted to their size, which is carefully lined with coarse silk, mixed up with particles of earth, so as to form a sort of outer wall to the winter retreat; —within this they construct a second cocoon of a softer fabric, in which to assume the chrysalis condition. In other species the plan is slightly modified: instead of digging into the ground, these content themselves with hiding under the bark of trees, or in old rotten stumps, where they weave their silken envelope, and patiently await their final change.

Many insects, (*Uroceridæ*), nearly related to the preceding, instead of simply sawing slits in the bark and leaves, bore deeply into the solid wood itself, by means of an apparatus very similar to that of the saw-flies, only much stronger, and constructed so as to act the part of an auger rather than that of a saw. Using this powerful borer the females deposit their eggs in sound timber. The larvæ hatched in this situation are furnished with strong horny jaws that cut the wood like chisels, so that when these insects are numerous, they do considerable damage, more especially in pine trees, which seem to be selected in preference, by the larger species, as depositories for their offspring. Sometimes, even in our own country, the mischief thus produced is considerable, whole trees being destroyed by the numerous burrows thus excavated in their interior. When full-grown, the larvæ construct silken cocoons mixed with chips of wood, in which they assume the pupa state. The pupæ greatly resemble the perfect insects, having all their limbs developed, but folded upon the sides of their body and breast, in which condition they remain until mature, when they creep out of their holes to go in search of other trees wherein to deposit their progeny.

The gall-flies (*Cynipidæ*) are likewise provided with boring ovipositors, wherewith they lay their eggs in various parts of plants, some attacking the leaves, others the branches, others the roots, and others the buds and tender shoots. It would seem, however, that along with the egg the *Cynips* introduces into the orifice made by its boring apparatus, some irritating fluid, which exercises a specific action upon the vegetable tissues, and causes the formation of peculiar excrescences, generally known by the name of "Galls." These galls are of very different size, shape, and texture, their peculiarities depending upon causes at present but very imperfectly understood. Each species of Cynips, however, selects its own particular plant, and by its puncture gives rise to galls, having a similar character, some of which are possessed of very valuable properties, and thus their history acquires additional importance.

The common oak-apple affords a good illustration of the manner in which galls are produced. These remarkable excrescences, the appearance of which is so well-known to every school-boy, owe their origin to a little insect, (*Cynips quercus*), whose portrait is given in the annexed woodcut (fig. 20), resting upon a leaf of its favourite oak. This species of Cynips, when about to lay eggs, selects the tender shoots of an oak tree in which to deposit them, and by means of its borer, soon succeeds in drilling a hole in the soft substance of the twig, in which an egg is laid. The tissues of the branch thus attacked, irritated apparently by the peculiar stimulus of the borer employed, or perhaps by the specific properties of some fluid with which they are at the same time inoculated, immediately begin to swell into a ball, in the centre of which the egg remains imbedded. Thus surrounded by an abundance of vegetable juices, the egg increases considerably in size, and soon bursting, gives birth to the larva of a Cynips, which finding itself imprisoned in the fleshy substance of the gall, its appointed

Fig. 20.



food, immediately begins to eat, and as its presence seems rather to stimulate than to check the growth of the gall, it is in no danger of being in want of provisions. In this condition the larvæ remain for five or six months, having the appearance of small grubs, destitute of feet, but furnished with little fleshy tubercles instead, which are quite sufficient for their wants. In the figure above given, one of these grubs is represented occupying a cavity in the centre of the oak-gall, which thus forms both its food and the abode in which it passes its pupa condition. When full-grown, some species eat their way out of the gall, leaving a round hole, indicating the point of exit, and dropping to the ground, there hide themselves to assume the pupa form.

The *Cynips rosæ* makes its punctures in the stems of the wild rose, and the galls to which it gives rise, well-known as the "bedeguar," resemble externally large balls of worsted, but within they are found to be fleshy, and well adapted to form the nourishment of the larvæ contained in their interior.

The most important of these insects is, however, the *Cynips gallæ tinctoriæ*, which causes the formation of the gall-nuts of commerce, employed in the manufacture of ink, and also extensively used in dyeing. These galls are produced from the *Quercus infectoria*, a species of oak common in the Levant, upon which, likewise, grow the *Mala insana*, or mad-apples, those

> "Dead-sea fruits that tempt the eye,
> But turn to ashes on the lips,"

which are also galls arising from the puncture of another Cynips. These excrescences, in short, assume very various shapes, according to the localities where they are found, but whatever their appearance, they are the depositories for the larvæ of these insects, one or more of which are always to be found in their interior, until they make their escape in the manner above described.

Our business, however, on the present occasion, is not so much to indicate the various forms of the boring apparatus employed by insects, or to expatiate upon the numerous modes of proceeding by which they are rendered efficient; it is rather our wish to call the attention of the reader to the widely-spread relationships, established by the possession of this simple instrument, between most dissimilar and remote departments of the organized creation, in order at least to obtain some slight idea of the mutual bearings and dependencies of the whole.

Numerous carnivorous birds are entirely dependent for their very existence upon the abundance of grub-worms, caterpillars, and various other larvæ, of which they devour incalculable quantities. To illustrate this, however, let us select but one species of bird, the red-winged starling of the United States of North America, concerning which, Wilson gives us the following interesting particulars. "If we suppose each bird, on an average, to devour fifty larvæ in a day (a very moderate allowance), a single pair in four months, the usual time such food is sought after, will consume upwards of twelve thousand. It is believed that not less than a million pair of these birds are distributed over the whole extent of the United States in summer; whose food being nearly the same, would swell the amount of such vermin destroyed, to twelve thousand millions. But the number of young birds may be fairly estimated at double that of their parents, and as these are constantly fed on larvæ for at least three weeks, making only the same allowance for them as for the old ones, their share would amount to four thousand two hundred millions, making a grand total of sixteen thousand two hundred millions of noxious insects destroyed in four months, by this single species of bird."

In commenting upon the above somewhat startling calculation, the American ornithologist observes, that the combined ravages of such a hideous host of vermin would be sufficient to spread famine and desolation over a wide extent of the richest and best cultivated country on earth. What then would be the consequences of their unchecked fertility? what the disastrous results, were it not that in the midst of these vast legions "keeps Death his court," and by the agency of countless unseen emissaries ("as with a little pin drills through the castle walls" of some poor victim, leaving that fatal summons which all obey at the appointed time,) prevents anarchy and famine from usurping the place of order and abundance?

Again, turning to the vegetable world, how inscrutable are those laws which make the very plants subservient to the grand design of Providence, each punctured bough or leaf at once responding to the appropriate stimulus, and furnishing to its insect suppliant the needful shelter and appointed food wherewith to rear its helpless progeny! Nevertheless, even these mysterious alliances are surpassed in wonder by some that await our notice, and which we next proceed to consider.

CHAPTER V.

INSECT INSTINCTS.

Few subjects present greater scope for observation, or more touchingly illustrate the wisdom and the beneficence of the Creator, than the instincts implanted in animals, enabling them to provide for the welfare of their progeny. Among the insect races such instinctive provisions are peculiarly requisite, and when the circumstances under which they are made are taken into consideration, must strike the most unobservant with astonishment, and impress upon every thinking mind a deep sense of the watchful care of that Providence whose eyes are over all his works. The parent insect, it will be observed in the great majority of instances, has to secure protection for a progeny over which she has no means of watching, and which, indeed, she is never destined to know, seeing that her term of life is ordinarily finished long before the eggs to which she gives birth are hatched; she has, moreover, to ensure for her future young a supply of food, consisting of aliment adapted to their tastes and appetites. Did this food resemble that upon which she herself lives, the task would be comparatively an easy one, as little more would be necessary than to hide her offspring in such situations as she herself frequents, where materials similar to those which yield her nourishment could easily be procured; but the case is far different; the habits of the mother and of the young are utterly dissimilar, and consequently the foresight which is displayed by the former, under circumstances of so much difficulty, becomes the more remarkable. We can select but a few examples to illustrate this position, but many others will doubtless suggest themselves to the reader.

The various butterflies that haunt our gardens, fluttering from flower to flower and sipping the nectar they furnish, might be supposed to select their own sweet food as affording a fit nutriment for their young, and rest satisfied with depositing their eggs upon the petals of favourite blossoms. What tells one of these insects, that the blossoms would be gone before her eggs were hatched, or that a coarser food, a particular plant, is essential to the support of the animals that must issue from them? Instructed, nevertheless, in some mysterious manner upon both these points, she quits her favourite haunts, and diligently seeking out the appropriate tree, or herb, securely deposits her eggs in such a manner that the nascent caterpillars shall find no difficulty in feeding themselves as soon as capable of eating.

Sometimes, moreover, it is not sufficient merely to select the proper plant adapted to afford nourishment to the future larvæ, but the eggs themselves must be carefully protected from external violence, or defended against the inclemencies of the weather; this is more especially necessary with such as, being deposited at the close of the year, have to remain unhatched until the ensuing spring, and thus require to be secured from the cold and wet of winter. Various contrivances are adopted for this purpose by different races of insects, but we shall here only advert to a few of the most remarkable examples illustrative of the habits of moths and butterflies.

Several kinds of moths (*Arctia*, *Hypogymna*, &c.) construct very beautiful and curious nests, impervious to wet, and entirely composed of hair stripped from their own bodies. With this material, which they tear off by means of their pincer-like ovipositor, they first form a soft couch on the surface of some leaf;* they then place upon it, successively, layers of eggs, and surround them with a similar downy coating: afterwards, when the whole number is deposited, they cover the surface with a roof of hairs, the disposition of which cannot be too much admired; those used for the interior of the nest are scattered without order, but those that are placed externally are arranged with as much art and skill as the thatch of a cottage, and as effectually keep out water; one layer of these hairs partially overlaps another, and all having the same direction, the whole resembles a well-brushed piece of shaggy cloth or fur. When the mother has finished this labour, which often occupies her for twenty-four hours, and sometimes for even twice that period, her body, which before was extremely hairy, is rendered almost wholly naked, she has stripped herself to clothe her offspring, and having performed this last duty of her life, she dies.

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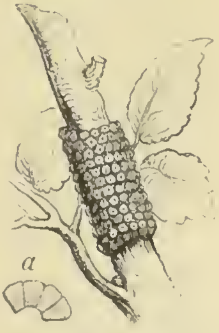
* Kirby and Spence, iv. p. 75.

Warned by an unerring foresight, many Lepidopterous insects, avoiding the leaves which in winter would fall off and be destroyed, select the *twigs* of the trees upon which their progeny are to be nurtured, to which they affix their eggs with admirable art and ingenuity. Among the most conspicuous of those species which thus provide for the security of their offspring, are the lackey-moths (*Lasiocampa*), whose eggs are found arranged in numerous circles around the tender shoots of fruit-trees, and so beautifully disposed, that they might be taken for pearls set by the hand of a jeweller, rather than for the eggs of insects. These zones, which are not inaptly called "bracelets" by the French gardeners, are composed of from two to three hundred eggs fastened around the twig, in a series of from fifteen to seventeen close spiral lines (fig. 21), and being imbedded in a tough brown gum or cement, the colour of which nearly approximates that of the bark of the tree, they are not only defended from injury but almost hidden from observation. Beautiful as these "bracelets" are, we should, however, leave unnoticed the most elegant part of the contrivance, did we omit one circumstance connected with their arrangement. Had these eggs been round

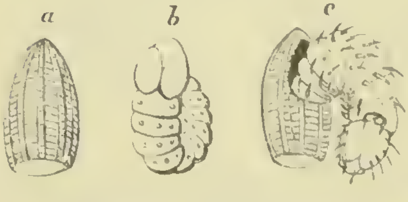
Fig. 21.



or oval, they evidently could not be thus made to encircle a branch, without a considerable waste of room, and, consequently, of material. A plan is therefore adopted whereby these inconveniences are completely avoided. Each egg of the Lasiocampa, instead of presenting the usual shape, has the figure of a cylinder flattened at both ends, the diameter of which gradually diminishes towards one extremity (fig. 21, *a*), when applied with their long axes perpendicular to the surface of the twig, therefore each of these eggs resembles the key-stone of an arch fitting exactly into the interspace between the two contiguous ones, so that the utmost economy of room is secured by this disposition and all waste of material avoided.

Being by the above, and various other ingenious contrivances, protected from injury, or screened from observation, the *eggs* of the Lepidoptera remain in security for a longer or shorter period; the time required for the development of the larvæ within, varying with the temperature of the season, or the exigencies of the species to which they belong, until at last the enclosed embryo is matured, and the newly-formed progeny proceeds to extricate itself from its investments, and break through its prison walls. We have in a preceding chapter described the condition in which the infant butterfly leaves the egg, and traced it through its caterpillar and chrysalis stages of life as far as

Fig. 22.



relates to the general features of the metamorphoses to which it is subject. There are, however, several interesting particulars connected with the progress of these changes, to which we have not as yet adverted.

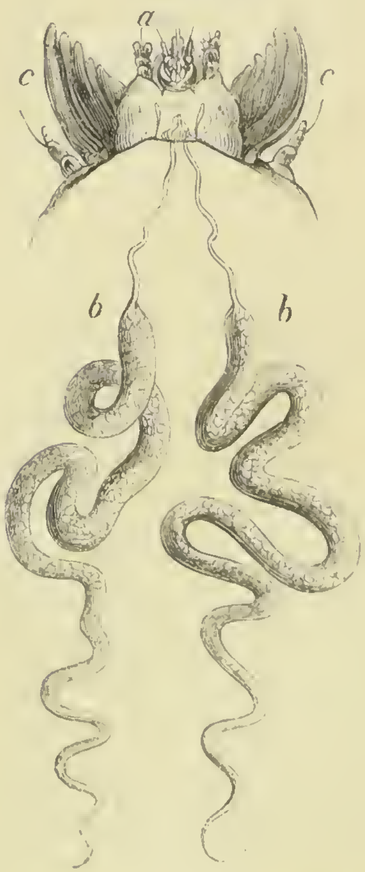
Perhaps the most striking feature in the economy of the Lepidopterous caterpillar, which however it possesses in common with many other larvæ, is the capability of manufacturing *silk*, a material so peculiar in its nature and so important in its uses, that it is scarcely an exaggeration to call it the most valuable of all natural productions. In making this assertion, we are not by any means alluding to its importance in a commercial point of view, or estimating how many pounds of this substance are annually imported by our merchants or manufactured in our looms, though to mankind it is doubtless both an element of wealth and an article of luxury.

These adventitious indulgences have been but very recently granted to human ingenuity, and might again be withdrawn without much detriment to the world at large; but long before the importance of the silken filament was known to man, it was employed among the insect tribes for the construction of various fabrics, not merely conducive to their comforts, but essential to their existence; and who can tell the nice dependences thus invisibly yet indissolubly interwoven?

The process adopted by nature for the fabrication of silk, is extremely simple, and the whole process easily to be understood. The machinery employed consists of a delicate tube called the spinneret (fig. 23 *a*), affixed to the lower lip of the larva;

this tube constitutes the external outlet of two long and flexuous reservoirs of fluid silk (fig. 23 *b b*), that are contained in the body of the caterpillar. When, therefore, a grub thus provided has need of a filament of silk in order to construct a cocoon, or for other purposes hereafter to be noticed, it has nothing to do but to cause a little drop of the glairy contents of its silk bags to exude through the little orifice at the extremity of its spinneret, and having affixed it to some foreign body, gently to pull back its head and thus draw out a semi-fluid thread that in the course of a few seconds hardens into a tenacious filament of silk, corresponding in thickness with the size of the orifice through which it is drawn; and if, as in the case of the silk-worm, this thread is carefully wound into a cocoon; its length may be produced until the whole of the supply of fluid furnished by the silk-bags becomes extracted.

Fig. 23.



Any one who would witness the operations of a caterpillar thus employed in the manufacture of silk, cannot have a better illustration of the process than is afforded by the common loopers, or geometric caterpillars (fig. 24), that employ their threads for the purpose of letting themselves down, as by a rope,

Fig. 24.

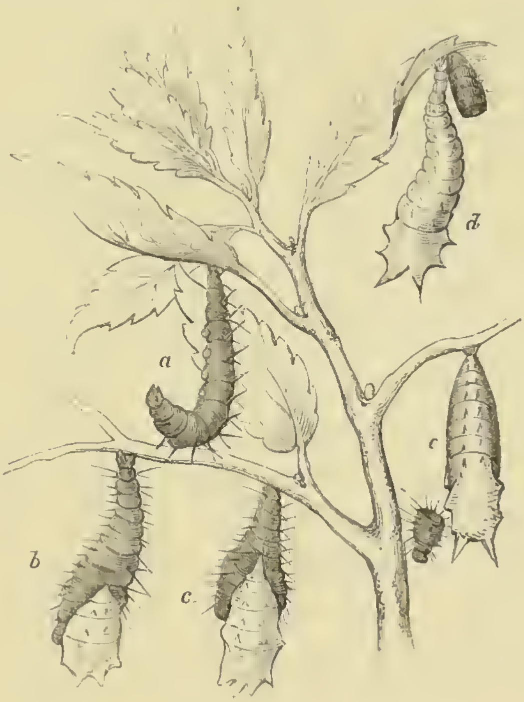
from one branch of a tree to another, and thus save themselves long and perilous journeys in search of food. The caterpillar fixes a drop of its silken secretion to the bough above, and gradually lengthening its line, swings securely at the end of the rope so formed, a proceeding which at first sight might appear simple and easy enough, did we not, on reflection, perceive that there are difficulties in the performance of this feat that are of apparently insurmountable character. To hang by a rope may require no extraordinary skill; but when it is remembered that, in the case of the caterpillar, the rope to which it is attached is necessarily fluid when first emitted from the spinneret, it seems hard to conceive how, under these circumstances, the caterpillar is to retain its hold; indeed nothing short of the most cautious and vigilant care could enable it to do so. The precaution adopted, nevertheless, completely answers the purpose: the caterpillar, with admirable precision, lets out no more of its liquid silk at once than will retain sufficient tenacity to bear its weight; it then pauses until the quantity thus emitted has become hardened into silk, and cautiously repeating the operation again and again, it lengthens out its rope by instalments, until it at last arrives at its destination. Some caterpillars employ their thread for the construction of rope-ladders, by the aid of which they will climb even the smooth sides of a glass jar in order to make their escape: this is effected by fixing their thread to the glass in a zigzag form, continuing to prolong their ladder in front as they mount it behind, until at last the top of their prison-wall is reached.

The chief use to which the silk is applied is, however, to furnish a defence for the caterpillar during the inactive and helpless condition it is reduced to on passing into the chrysalis state, by enabling the larva to construct a covering adapted for its concealment, the nature of which varies with the habits of the species: sometimes it forms merely a thin fleecy web, scarcely thick enough to hide the included insect; at others a cocoon is prepared of considerable thickness and consistency, such as that of the silk-worm. Many species contrive to roll up the leaves of plants, so as to form an exterior citadel, within which a silken couch is woven for the protection of the secluded insect; or, in some instances, troops of caterpillars work together in company, and erect a kind of tent, which is intermixed with foliage, and serves as the common lodgement of their numerous company. Frequently, for the purpose of ensuring still more effectual concealment, divers foreign matters are introduced with incomparable skill in the construction of this silken covering, such as the fragments of sticks, moss, earth, leaves, or even the hairs from the surface of the caterpillar's own body; in short, by an infinite diversity of admirable contrivances these curious envelopes are protected as much as possible from observation, and consequently from the attacks of other animals.

Many races of Lepidopterous insects, at the approach of their transition from the caterpillar to the chrysalis state, instead of employing their silk in the construction of a cocoon, are able by its assistance to suspend themselves in some secure retreat, and thus to remain hanging, out of the reach of attack, during the continuance of their helpless condition as pupæ. The species which adopt this precaution are for the most part true butterflies, such as the common peacock-butterfly and cabbage-butterfly of our gardens, and may be divided into two great classes, — those which hang themselves *perpendicularly* by the *tail*, and those which suspend themselves *horizontally* by means of a girth placed around their middle; and when we consider that it is the *chrysalis* which has to be suspended, while the process of suspension is the work of the *caterpillar*, we become naturally curious to know how the operation can possibly be accomplished. The difficulties, indeed, appear insurmountable, as will be at once evident to the reader, from the following account of the plan employed, derived from the delightful pages of Messrs. Kirby and Spence. The filament of silk being afforded in the manner described above, the larva has to suspend itself from some foreign body. But how? How is a caterpillar to suspend itself by the tail to threads spun from the mouth? Even supposing this difficulty overcome, others still greater remain. Suppose the caterpillar to be suspended by its tail,—this is but a preparatory operation—what is required is, that the pupa shall hang in the same position. Now, when we take into consideration that it is encased *within* the skin of the larva, and is destitute of feet or other external organs; that it has to extricate itself from this skin; to hang itself in its place, and then to detach the skin from the threads that hold it—this will appear no trifling task. Indeed at first view it seems impossible. Country fellows, for a prize, sometimes amuse the assembled inhabitants of a village by running races in sacks: take one of the most active and adroit of these, bind him hand and foot, suspend him, by the bottom of the sack with his head downwards, to the branch of a lofty tree; make an opening in one side of the sack, and set him to extricate himself from it, to detach it from its hold, and suspend himself by his feet in its place. Though endowed with the suppleness of an Indian juggler, and promised his sack full of gold for a reward, you would set him an absolute impossibility: yet this is what our caterpillars, instructed by a beneficent Creator, easily perform.

When the caterpillar has selected the under side of the leaf, or other object to which it purposes suspending itself, its first process is to spin upon it a little hillock of silk, consisting of numerous loosely interwoven threads; it then bends its body so as to insinuate the anal pair of prolegs amongst these threads, in which, by a slight exertion, the little crotchets which surround them become so strongly entangled as to support its weight with ease. It now suffers the anterior part of the body

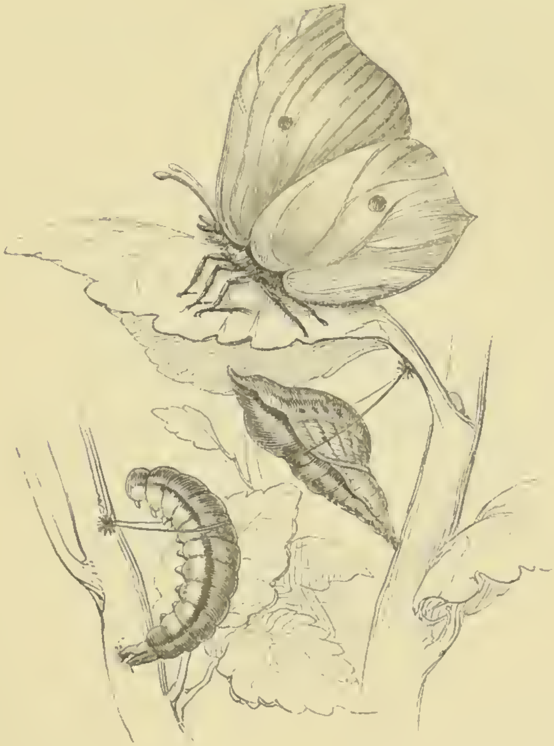
Fig. 25.



to fall down, and it hangs perpendicularly from its silken support, with its head downwards (fig. 25, *a*). In this position it remains often for twenty four hours, at intervals alternately contracting and dilating itself. At length the skin is seen to split on the back, near the head, and a portion of the pupa appears, which by repeated swellings acts like a wedge, and rapidly extends the slit towards the tail (*b*, *c*). By the continuance of these alternate contractions and dilatations of the conical pupa, the skin of the caterpillar is at last collected in folds near the tail, like a stocking which we roll upon the ancle before withdrawing it from the foot. But now comes the important operation. The pupa being much shorter than the caterpillar, is as yet at some distance from the silken hillock on which it is to be fastened: it is supported merely by the unsplit terminal portion of the latter's skin. How shall it disengage itself from this remnant of its case, and be suspended in the air while it climbs up to its place? Without arms or legs to support itself the anxious spectator expects to see it fall to the earth. His fears, however, are vain; the supple segments of the pupa's abdomen serve in the place of arms. Between two of these, as with a pair of pincers, it seizes on a portion of the skin; and bending its body once more, entirely extricates its tail from it. It is now wholly out of the skin, against one side of which it is supported, but yet at some distance from the leaf. The next step it must take is to climb up to the required height. For this purpose it repeats the same ingenious manœuvre, making its cast-off skin serve as a sort of ladder, it successively with different segments seizes a higher and a higher portion, until in the end it reaches the summit, where with its tail it feels for the silken threads that are to support it. But how can the tail be fastened to them ? you ask. This difficulty has been provided against by Creative Wisdom. The tail of the pupa is furnished with numerous little hooks pointing in different directions, as well adapted to the end in view as the crochets of the larva's prolegs, and some of these hooks are sure to fasten themselves upon the silk the moment the tail is thrust amongst it. Our pupa has now nearly completed its labours (*d*); it has withdrawn its tail from the slough, climbed up, and suspended itself to the silken hillock,—manœuvres so delicate and perilous, that we cannot but admire that an insect which executes them but once in its life, should execute them so well; nor could it, as Réaumur has well and piously observed, had it not been instructed by a Great Master. One more exertion remains; it seems to have as great an antipathy to its cast-off skin, as one of us should, when newly clothed after a long imprisonment, to the filthy prison garments we had put off. It will not suffer this memento of its former state to remain near it, and is no sooner suspended in security than it endeavours to make it fall. For this end, it seizes, as it were, with its tail, the threads to which the skin is fastened, and then very rapidly whirls itself round, often not fewer than twenty times. By this manœuvre it generally succeeds in breaking them, and the skin falls down (*e*). Sometimes, however, the first attempt fails: in that case, after a moment's rest, it makes a second, twirling itself in an opposite direction; and this is rarely unsuccessful. Yet, now and then, it is forced to repeat its whirling, not less than four or five times; and Réaumur has seen instances where the feet of the skin were so firmly hooked, that after many fruitless efforts, the pupa, as if in despair, gave up the task and suffered it to remain. After these exertions, it hangs, the remainder of its existence in this state, until the butterfly is disclosed.

We are now to consider the *second* mode of suspension, in which, larvæ, by means of a silken girth round their middle, fix themselves *horizontally* under leaves, &c. These follow the same process with those last described, in spinning a small hillock of silk, to which they fasten their hind legs; and if the operation concerned the larva state alone, this would be sufficient, as by means of their support, aided by their prolegs, they could easily retain themselves in an horizontal position. But these larvæ act as if they foresaw the assumption of a state in which they will be deprived of legs. It is the suspension of the forthcoming pupa that is the object in view; and though this can be hung by the tail in the same way with those of the first class, yet it is plain that it cannot be retained in an horizontal position, which for some unknown reason is essential to it, without support to its anterior extremity. It is necessary for the larva, therefore, not only to fix its posterior legs amongst a collection of silken fibres, but to spin a girth of the same material round its body. This girth, though apparently of a single thread, will be found on examination to be composed of several, often as many as fifty or sixty; and is fastened on each side of the body of the larva, about the middle, to the surface under which it is placed (fig. 26). Three different modes of fixing these girths are adopted by the caterpillars of different butterflies. Some, as those of the common cabbage butterfly (*Pontia brassica*), which have remarkably pliable bodies, bend them almost double on one side, then fix the thread and carry it over to the other in the same position, re-

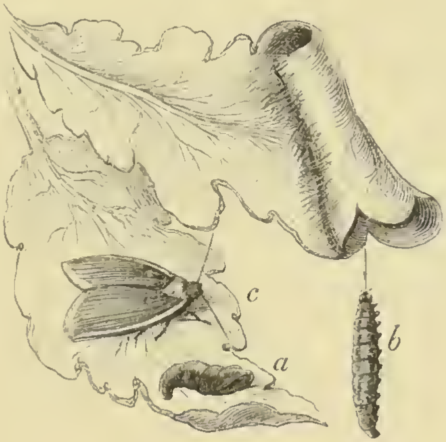
Fig. 26.



peating this operation as often as is necessary. Others, as that of the *Polyommatus Argus*, and many more which have a short and more rigid body, after having bent the head on one side so as to fix one end of the thread, bring themselves into a straight position, and by a manœuvre not easily described, contrive to introduce the head under the thread, which they then bend themselves to fasten on the other side, pushing it to its proper situation by the successive tension and contraction of their segments. But the most curious mode, though indeed that which seems most natural, is adopted by the caterpillar of the beautiful swallow-tail butterfly (*Papilio Machaon*), and others of the same family. This first forms the loop which is to serve for its girth, and then creeps under it. But the difficulty it has to surmount is, to keep itself from being entangled in the fifty or sixty fine distinct threads of which the girth is composed, and to preserve them all extended, so as to be able to introduce its body beneath them. For this purpose it makes use of the first two pairs of its legs, employing them as a woman does her hands in winding a skein of cotton, to collect and keep all the threads unentangled and properly stretched ; and it is often with great difficulty, towards the end of the process, that it prevents them from slipping off. When a sufficient number of threads is completed, the animal bends its head between its legs, and insinuates it under the collected loop, which by its annular contraction it easily pushes to the middle of the body.

In about thirty hours after the larvæ which girth themselves have finished their operations, the skin splits, and the pupa disengages itself from it by those contractions described, pushing the exuviæ in folds to the tail, by different movements of which it generally succeeds in detaching them. One would have thought there would be considerable difficulty in slipping the skin past the girth; but this, according to Reaumur, seems to be easily effected.

Fig. 27.



A very considerable number of Lepidopterous larvæ, known by the name of "leaf-rolling caterpillars" (fig. 27, *a b c*), construct for themselves a remarkable residence, formed of the leaves of a variety of plants, concealed by which they spin their cocoons, and remain sheltered from injury during their pupa condition. Numerous are the forms of these leaf-built habitations; but in all the ingenuity employed in their construction is equally admirable. We must, however, confine ourselves to one or two illustrations of the process by which the little caterpillars accomplish their object. Where the leaf is to be simply rolled up into a cylindrical case, the operation might not appear very difficult; yet when we consider its elasticity and the strength of its ribs and nervures, we are naturally tempted to inquire how a little grub, quite destitute of hands, or fingers, wherewith to work, can manage to perform such a task; and, moreover, to retain the leaf in its artificial position. The work is accomplished in the following ingenious manner: the little labourer first begins by spinning silken threads, which it fastens to the edge of the leaf by one end, whilst the other is attached to a distant part of the leaf's surface,—she then pulls at these cables, one after another, with her feet, so as at each effort to bend the edge of the leaf a little inwards, in which position she fastens it by means of additional threads. This operation is repeated again and again; and as the ropes are thus progressively shortened, the leaf becomes gradually folded more and more, until at length it is bent into a roll, and securely tied in that position by innumerable silken filaments of sufficient strength to resist the resiliency of the material employed.

Some caterpillars, instead of rolling the entire leaf, cut out a long triangular portion, by means of their jaws, which they roll into the shape of a hollow cone, and afterwards raise upright upon its base, by fixing little cables near its apex, and then dragging it into a perpendicular position by the weight of their bodies, take up their residence in this leaf-built pyramid. Others tie several contiguous leaves together; and sometimes whole companies combine to construct a residence of this description, in which they reside in common until their metamorphoses are completed.

Many of the smaller moths (*Tineidæ*) construct for themselves moveable tents, made out of the leaves upon which they feed, and these they carry about with them almost in the same manner as a snail does its shell. These singular abodes are manufactured out of the thin cuticle which covers the upper and under surfaces of the leaf, and nothing can be more ingenious than the mode in which they are constructed. The caterpillars first eat their way into the parenchyma or pulp, placed between the membranes covering the upper and under surfaces of the leaf, to a sufficient extent for their purpose, without injuring the membranes themselves, which, when thus deprived of the enclosed pulp, appear white and transparent. The caterpillar then cuts the membranes of the leaf with the greatest skill, shaping them as nicely as a tailor would a piece of cloth; it then proceeds to fasten their edges together with its silk, joining them with the greatest accuracy, until its little tent is completed, which it then proceeds to detach from the leaf and carries away on its back.

Many species of kindred habits construct their edifices upon the surfaces of walls, building them of particles of stone or brick, most artificially bound together with cords of silk. Each of these cells is in the shape of a cone, open at the bottom, and is carried about by the little creature wherever it goes, until the time approaches for its conversion into a chrysalis, when the larva firmly fixes the mouth of its habitation to the surface of the wall by a strong silken web; taking care, however, to leave a free passage through which it may escape when it has acquired wings, and, thus ensconced, it securely passes through its pupa condition of helplessness.

Other larvæ of moths, unfortunately but too well known from the destruction which they cause, inhabit various animal productions, such as furs, woollen cloths, and other similar substances, which not only serve them as food, but furnish them with the materials for building the habitations wherein they live during the preparatory stages of their existence. These, likewise, belong to the family Tineidæ, and have received various names from entomologists, such as the fur-moth (*Tinea pellionella*), the tapestry-moth (*Tinea tapetzella*), the wool-moth (*Tinea vestianella*), the cabinet-moth (*Tinea destructor*), the last of which makes fearful ravages in cases of stuffed birds, or amongst collections of insects; but they all agree in their general habits, constructing for themselves cases composed of particles of wool, hair, or feathers, which they shear off with their teeth and bind together by silken filaments with wonderful ingenuity.

Chrysalises, even derived from the same brood of caterpillars, do not all arrive at maturity at once, but sometimes at very distant intervals. An example of this is recorded in the "Linnean Transactions." Out of thirty-six caterpillars produced from the same brood of eggs, all of which spun their cocoons and went into the chrysalis state at the usual time, twelve only made their appearance at the proper season; twelve others were hatched the next year, and the remaining twelve did not assume the imago state till the third season from their birth. In commenting on this remarkable phenomenon, we cannot but agree with Kirby and Spence, that the object of such an arrangement is the prevention of all possibility of the destruction of the species, in support of which view they adduce many interesting facts, of which, however, the following will answer our present purpose (*Eriogaster lanestris* and *Spilosoma mendica*), two species of Lepidopterous insects, are doomed, for some reason unknown to us, to be disclosed from the pupa in the cold and stormy months of February and March, almost every day of which in certain years is so ungenial that few insects could then survive exposure, much less deposit their eggs and ensure the succession of a progeny. Now, were all these to make their appearance in the *same* year, it might happen that the whole race, in a particular district, would be destroyed. But this possibility is effectually guarded against by the beautiful provision under consideration, it being very improbable that three successive seasons should be throughout unfavourable, and without such an occurrence it is clear that some of the race of this moth will be preserved.

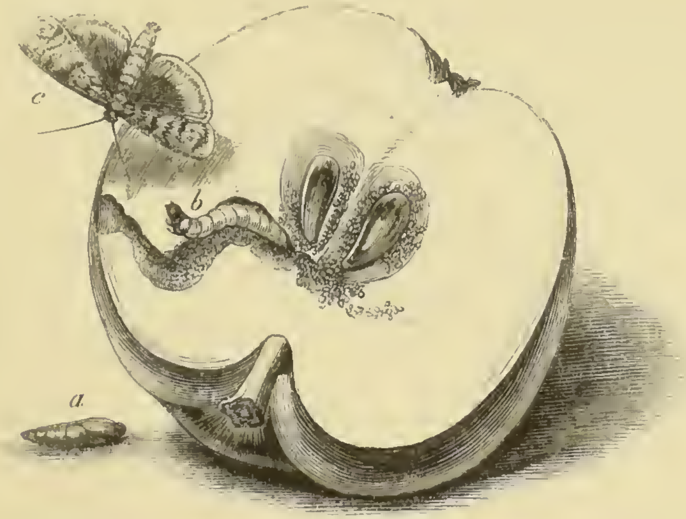
In the case of other moths whose pupæ are disclosed in summer, the prevention of the extinction of the species by any extraordinary increase, in a particular year, of their natural enemies, seems the object in view. But though the intention be obvious, the means by which it is effected are impenetrably concealed. "What physiololgist would not be puzzled with the eggs of a bird of which one-third should require to be sat upon only a fortnight, another third a month, and the remainder six weeks?"

Whatever length of time may be passed in the chrysalis state, the object attained by the incarceration of the concealed insect is the same—namely, the completion of the development of those new limbs and more perfect organs, which are characteristic of its last or winged state.

The extent of the changes that occur during this condition, cannot perhaps be better exemplified than by observing what transpires during the conversion of the mouth of the caterpillar into that of the perfect insect.

The caterpillar, destined to feed upon the coarsest food, presents in the structure of its mouth, a set of shears adapted to cut and devour the crude leaves of the vegetables upon which it feeds, or the tough animal substances, such as hair, or wool, which in some instances are the objects of its attack. In the larva condition, therefore, the mouth, as already described, resembles in many respects that of a mandibulate insect, and consists of similar parts. Above, it is closed by a broad transverse corneous plate, or labrum, which forms its anterior boundary; beneath which is found a pair of strong, horny, curved, and toothed jaws (mandibles), which open and shut laterally like the blades of a pair of scissors, and which, from their sharpness, are well calculated to cut the most refractory animal or vegetable substances. Immediately beneath these there is another pair of transversely moving jaws (the *maxilla*), which are, however, of a softer and more membranous texture, being rather adapted for holding than for dividing the food, and which being furnished with two little palpi, or feelers, are, perhaps, employed as tactile organs for examining the quality of the substances devoured. Inferiorly the mouth is closed with a second transverse plate (the *labium*), upon which the spinneret is situated, and which is likewise furnished with a pair of minute palpi, that serve most probably as instruments of sensation.

Fig. 28.

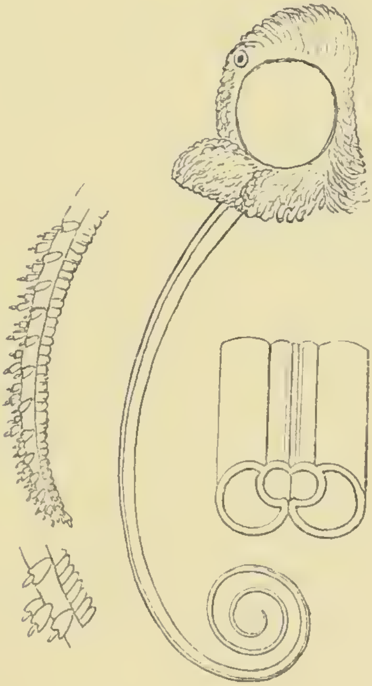


The use of such a mouth as this is obviously to cut; and any one who has watched a caterpillar feeding upon a cabbage-leaf, or a silk-worm devouring the leaves of a mulberry-tree or lettuce, will at once acknowledge their efficiency for this purpose.

But how different the uses to which the mouth of the butterfly must be subservient, whose food, instead of consisting of crude vegetable materials, is entirely derived from the honeyed juices of flowers sucked up from the recesses of the flower-bells, and which, consequently, must be imbibed by means of an apparatus specially contrived for such a purpose. Nothing, in truth, can be more astounding than the complete change which is effected in this part of the structure of the insect during its seclusion in the chrysalis case. The mandibles, or cutting horny jaws, which formed such important parts of the mouth of the caterpillar, are nearly obliterated; while the maxillæ assume a development and importance which render them the principal agents in taking up food; and, indeed, present a complexity of mechanism rivalling even that of the elephant's proboscis. These maxillæ, when not in use, are rolled up like the spring of a watch, beneath the head of the insect, but can be unfolded in an instant, and protruded, in some species, to the length of an inch or more. The organization of these maxillæ, which constitute what is vulgarly called "the tongue" of the butterfly, is inconceivably delicate, each consisting of an immense number of rings, moved by innumerable muscles; and thus, like the trunk of the elephant above alluded to, capable of every variety of movement. Its minute structure is equally wonderful, as may be seen from the following abbreviation of the description of this singular apparatus given by Mr. Newport.*

Each maxilla is convex on its outer surface, but concave on its inner, so that when the two are approximated they form a tube by their union, through which fluids may be drawn into the mouth. The inner or concave surface, which forms the tube, is lined with a very smooth membrane, and extends throughout the whole length of the organ, along its anterior margin; but that each maxilla is hollow in

Fig. 29.



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* Cyclopedia of Anat. and Physiol., Art. Insecta.

its anterior, so as to form "in itself a tube," as it is generally described to be by authors, is a mistake which has doubtless arisen from the existence of large tracheæ, or breathing tubes, in the interior, of each portion of the proboscis. In some species the extremity of each maxilla is studded externally with a great number of minute papillæ, as in Vanessa Atalanta (fig. 29), in which they are little elongated barrel-shaped bodies, terminated by smaller papillæ at their extremities: these, judging from their structure, and from the circumstance that they are always plunged deeply into any fluid which the insect takes as food, Mr. Newport supposes may be organs of taste. There are, also, some curious appendages arranged along the inner anterior margin of each maxilla, in the shape of minute hooks (fig. 29), which, when the proboscis is extended, serve to unite the two halves together. These are so exceedingly minute and arranged so closely, that their true form is with difficulty distinguished. They lock across each other like the teeth in the jaws of some fishes; and Mr. Newport is inclined to believe that the points of the hooks on one half of the proboscis, are inserted when the organ is extended, into little depressions between the teeth of the opposite side, so that they form the anterior boundary of the canal.

Such being the structure of this wonderful organ, it remains to inquire how, by means of the mechanism described, the insect is enabled to pump into its mouth the fluid nourishment upon which it subsists. Concerning this part of our subject, various opinions have been given by entomologists;—the following, however, derived from the observations of Mr. Newport, already quoted, appears the most satisfactory. On alighting on a flower the insect makes a powerful expiratory effort, by which the air is expelled from the air-tubes contained in the proboscis, and from those with which they are connected in the head and body; and at the moment of applying its proboscis to the food, it makes an inspiratory effort by which the central canal in the proboscis is dilated, and the food ascends it at the instant to supply the vacuum produced, and thus passes into the mouth and stomach; the constant ascent of the fluid being assisted by the action of the muscles of the proboscis, which continues during the whole time that the insect is feeding. "By this combined agency of the acts of respiration and the muscles of the proboscis," says Mr. Newport, "we are enabled to understand the manner in which the humming-bird sphinx extracts, in an instant, the honey from a flower while hovering over it, without alighting, and which it certainly would be unable to do so rapidly were the ascent of the fluid dependent only upon the action of the muscles of the organ."

CHAPTER VI.

COLEOPTERA.—BEETLES.

> See her bright robes the butterfly unfold,
> Broke from her wintery tomb in time of May!
> What youthful bride can equal her array?
> Who can with her for easy pleasure vie?
> From mead to mead with gentle wing to stray,
> From flower to flower on balmy gales to fly,
> Is all she has to do beneath the radiant sky."

Thus sings the Bard of the Seasons concerning the gaily painted tribes of flutterers that formed the subject of our last chapter; the reader must, however, now prepare to enter upon a scene of very different character, and cultivate the acquaintance of less elegant and attractive forms of insect life—the working classes of that vast community. The nectar-sipping syphon and the wing of velvet must now be changed for ruder weapons, and a working garb adapted to the rugged toil and every-day employment of vast hosts of sturdy labourers busily employed in every part of Nature's wide domain. The very dress of a beetle bespeaks the rough life to which it is appointed—the outer pair of wings, transformed in texture and converted into dense and leathery shields, no longer serve for flight, but act as simple cases, under which the second pair is neatly folded up and packed away, except on rare occasions, when necessity commands their use. The legs are cased in solid armour, and the feet provided with strong hooks wherewith to take firm hold: the jaws are formed for different kinds of work in different races; sometimes strong tearing fangs, more terrible than those that arm the tiger's mouth, betray the butcher and denote a life of carnage; others have grinding teeth to bruise and crush their food; some slice by means of horny knives the softer parts of plants, or else attack with variously constructed instruments the hardest vegetable substances.

The number of these insect "operatives" is truly prodigious; upwards of thirty-five thousand distinct species are already enrolled upon the catalogues of the entomologist, and in the opinion of the best judges it is more than probable that that number might be doubled or even trebled, were the list of existing forms completed.

In order to give the reader some idea of the general scope of the labours of these industrious legions, it will be necessary hastily to review their vast array.

The first division of this mighty army comprehends the Tiger Beetles, conspicuously the most rapacious and blood-thirsty of the race, equally remarkable for the beauty of their colours, their extreme activity, and savage propensities.

The larvæ of these insect-tigers are tolerably agile in their movements, and present a very remarkable appearance (fig. 30), the eighth segment of their bodies, which is larger than the rest, being armed with a pair of sharp recurved hooks, implanted in a prominent fleshy retractile cushion. These larvæ excavate cylindrical burrows in the ground, which are many of them upwards of a foot in depth, in the construction of which the larvæ exhibit extraordinary ingenuity, loosening the earth by means of their powerful jaws, and carrying it to the surface upon their broad heads, the hooks upon their backs assisting them to climb to the top, much in the same way as a chimney-sweep ascends a chimney. Their den being completed, they station themselves just within its entrance, where they lie in wait for any poor passing insect traveller that may be luckless enough to approach too near, when it is instantly seized and dragged to the bottom of the cave, there to be speedily devoured.

Less active, but scarcely less carnivorous in their habits, are the predaceous ground-beetles (*Carabidæ*), many of which are constantly employed prowling about upon the surface of the ground, in search of insect prey, lurking in the day-time under stones and other similar places of concealment, and carrying on an unrelenting warfare against innumerable noxious insects, the destructiveness of which they materially assist in diminishing. Among these marauding beetles, the most remarkable are the *Bombardiers* (*Brachinidæ*), as they are not inappositely named, several species of which are provided with a means of defence unparalleled among the lower animals. Of all the inventions which mankind seems fairly entitled to claim, as being exclusively of human contrivance, perhaps that of guns and gun-powder might be deemed the most original, yet even in this, strange to say, he has been forestalled. The little bombardier beetles possessed an artillery of their own long before the fields of Cressy first trembled at the unaccustomed roar of human cannon, as any one will confess, who may inadvertently lay hold of one of these living batteries. It is quite true, that neither powder nor ball is needed by the insect cannoneer, but there is the flash, the smoke, the report, and although

> "The far-hissing globe of death"

be wanting, its place is most efficiently supplied by a burning drop, so caustic in its nature as to be only comparable to nitric acid in its corrosive effects.

Sternly and unremittingly is the work of destruction entrusted to the carnivorous beetles carried on, by night as well as by day, without remorse or respite; and were we to reflect for a moment, we should soon perceive how indispensable is their murderous zeal, to the order and well-being of surrounding nature. Let us take one species, by way of illustration.

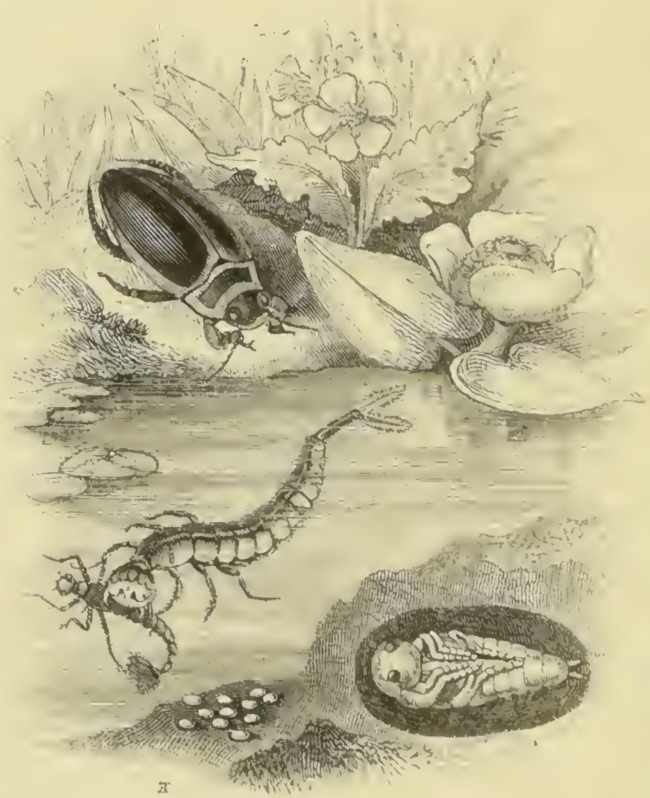
The *Calosoma sycophanta*, one of the most beautiful of the predaceous beetles, is very common in the pine forests of Germany, where, says Mr. Slater, in a recent number of the "Zoologist," they spangle the sand and the tree trunks like living gems. The splendour of its elytra, green, gold, scarlet, orange, the rich purple black of the thorax, the rapidity and ease of its movements render it a pleasing object even to the most careless. Except from the collector, however, it has nothing to fear, its utility to man being both known and appreciated. The pine forests of this country are exposed to the ravages of various Lepidopterous insects, such as *Smerinthus pinastri*, and in particular *Gastropacha pini*. Now, a pine tree once stripped of its leaves, or *needles*, as the Germans term them, does not recover like an oak or a sycamore, but dies. Many hundred acres of the finest timber are thus often destroyed in one district. It is an interesting sight to any but the owner to visit a forest under the infliction of *Gastropacha pini;* the thousands of caterpillars eagerly feeding, produce a distinct crackling sound as the hard dry pine-leaves yield to their persevering jaws. The large moths fluttering lazily about, or perched on the leafless sprays, await the approach of evening, when the gamekeepers kindle large fires in the open spaces. Into these multitudes of the moths fall and are consumed: but this, with all that are destroyed by hand or devoured by birds would avail but little, but for the services of certain insects. Among these the Calosoma is one of the most active; both larva and beetle mount the trees, and slaughter moths and caterpillars far more than are requisite to satisfy their appetite. Those seasons in which the pine moth is most numerous, are also remarkably favourable to the Calosoma, and to several kinds of Ichneumons, which also prey upon the Gastropacha.

The active operations of these destroyers are not, however, restricted to the land; many species are inhabitants of the water, and in that element have their assigned tasks to perform. Neither are the blood-thirsty propensities they exhibit only manifested during their mature or winged state; from their earliest birth they are tutored to the work of destruction, and their very infancy is devoted to carnage and slaughter.

Such being the destiny of these aquatic tribes, the reader will be prepared to learn, that in their structure, and in the character of the metamorphosis they undergo, the water-beetles differ remarkably from the terrestrial races, insomuch that in their larva condition no creatures could be more dissimilar. Any one must perceive at a glance, that a grub, such as that of the stag-beetle, figured in a preceding page, could no more exist in water than a fish upon dry land; its sluggish and unwieldy carcass would at once sink helplessly to the bottom, where it would speedily be drowned, seeing that the breathing-holes upon its sides, being only adapted to respire air, would be rendered useless when immersed in the denser fluid.

The larvæ of the water-beetles are, therefore, specially organized, with a view to their residence in another element, surrounded by enemies, and dependent altogether upon their own active energies for the means of subsistence. We will select for an example the *Dyticus marginalis*, one of the most common, and, at the same time, the most ferocious of all the insect inhabitants of our ponds, and which the young naturalist will have no difficulty in procuring for examination. These beetles in their perfect state exhibit in a very striking manner the facility with which, by slight modifications in their form and arrangement, the limbs of an insect become convertible to the most opposite uses. The body of the Dyticus, oval in its shape, and slightly flattened above and below, is converted into

Fig. 30

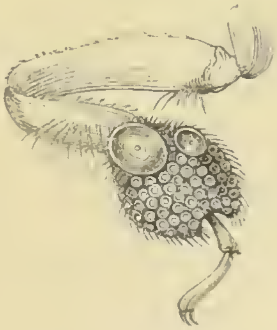


a boat, so smooth and polished in every part that it glides through the water with scarcely the slightest resistance, while the two hinder pairs of legs are changed into oars of most effective and elegant construction, each of them presenting a broad surface fringed with stiff hairs, wherewith to strike the water, and at the same time so accurately adjusted, in relation to the centre of inertia, from the mode of their attachment to the body, that our shipwrights could not possibly find a better model for study than one of these living skiffs.

The fore-legs are short and adapted to a different use, those of the male especially being formed into instruments of prehension of a very extraordinary character. The upper joints of the foot are expanded into a broad shield-like plate, upon the under surface of which are numerous circular cups of different sizes, each having its margin surrounded with a fringe of stiff hairs, and altogether constituting an apparatus of singular beauty (fig. 31).

Thus limbed, the Dyticus is fully equipped for its piratical mode of life, and becomes an object of no little interest in the water over which it tyrannizes. Sometimes lurking beneath the weeds, it may be seen creeping stealthily about, in search of some victim to seize by surprise; sometimes launching its skiff upon predatory excursions, the little corsair sweeps along by means of its oars with wonderful rapidity, coming every now and then to the top of the water to breathe, and diving again into the depths below, carrying with it a

Fig. 31.



supply of air beneath its wing-covers, to serve for respiration during its immersion. The powers of flight of these beetles are equally conspicuous, and they may frequently be seen to leave the water in search of some distant pond, or to drop, as it were, out of the air into any pool that may seem to invite a visit. Occasionally they have been known to mistake the glass of a cucumber frame for a sheet of water, and, throwing themselves unhesitatingly upon the shining surface, have met with but an inhospitable reception.

The young of these water-beetles are as active and ferocious as the adult insects, although widely dissimilar in point of form. These larvæ, sometimes not inappropriately distinguished by the name of "water-tigers" (fig. 30), have some resemblance to a scolopendra, their bodies being composed of a succession of scaly rings, and they are, moreover, furnished with six strong and well-jointed legs, by means of which they run about with considerable activity. The head, which is attached to the body by a flexible neck, is broad, and composed of strong horny plates, adapted to support the formidable jaws, which are powerful hooked fangs, moving laterally, and so sharp that woe betide the unfortunate creature on which they happen to lay hold. Thus armed, these creatures live upon other aquatic animals, upon which they rush with all the voracity of a shark or a pike, not sparing even individuals of their own species. When at rest, these larvæ suspend themselves at the top of the water, by means of two fringed, membranous, fin-like appendages, which being kept above the surface, and thus exposed to the influence of the atmosphere, serve, likewise, as respiratory organs; and when they swim, these caudal plates are used as paddles, by the aid of which the creature propels itself through the water.

After having several times cast their skin, and attained their full growth, these larvæ prepare to assume their pupa state, and for that purpose creep out of the water, in which they have hitherto passed their lives, and bury themselves in the moist earth in the vicinity of their native pond; each scooping out for itself an oval cavity, like that represented in the figure (fig. 30), wherein to pass the assigned period of helplessness and inactivity.

Those naturalists who favour the system of representation, of course find in the rapacious races of beetles the analogues of the eagles, the hawks, and the kites, among the feathered tribes; both are equally organized to combat and to kill; both strike at living game, and consequently stand pre-eminent in strength and courage. But, as among the flesh-devouring birds, species exist possessing more ignoble attributes, not formed for open battle but content to appease their ravenous appetites with carrion and such offal: so among the insects, numerous hordes exist whose prey is garbage and whose whole employment seems to be to search for and remove the dead remains of other animals. Everywhere these scavengers are busy; some frequent the muddy margins of our pools and ditches, eagerly in quest of rotting prey; others prefer the land, where they seek out, with unremitting diligence, whatever from decay begins to taint the air; while some, the very sextons of creation, bury whole the carcasses they meet with, and thus vigorously assist in carrying out the sanitary laws of Nature. Of the last-mentioned races the "burying-beetles" (*Necrophori*) offer remarkable examples; their instinct teaching them to bury every kind of dead flesh, either for their own food or as provision for their young, mice, rats, birds, frogs, moles, or even dead dogs and cats, are all provided with a tomb by these indefatigable grave-diggers, at the expense of no little labour and fatigue. An anonymous writer in the "Entomological Magazine," gives a very interesting account of the proceedings of these "sexton-beetles," from which it appears that they generally hunt in couples, male and female; and where a number are found congregated around a large animal, they are almost sure to be males and females in equal numbers. They hunt by scent only, their excursions being mostly performed when no other sense would be available, namely, by night. When they have found a dead animal, as for example, a bird, great comfort is expressed by the male, who wheels round and round above it, like a vulture over the putrefying carcass of some giant of the forest; the female settles upon it at once without this testimonial of satisfaction; the male at last settles also, and a savoury and ample meal is made before the great work is begun. After the beetles have appeased the calls of hunger, the bird is abandoned for a while; they both leave it to explore the earth in the neighbourhood, and ascertain whether there is a place suitable for interment; if on a ploughed field there is no difficulty, but if on grass or among stones, much labour is required to draw it to a more suitable place.

The operation of burying is performed almost entirely by the male beetle, the female mostly hiding herself in the body of the bird about to be buried, or sitting quietly upon it and allowing herself to be buried with it. The male begins by digging a furrow all round the bird, at the distance of about half an inch, turning the earth outside; his head is the only tool used in this operation; it is held sloping outwards, and is exceedingly powerful. After the first circuit is completed, another is made within that, and the earth is thrown into the first furrow; then a third trench is made, and this is completely under the bird: so that the beetle, whilst working at it, is out of sight, and the operation can only be traced by the heaving of the earth, which soon forms a little rampart round the corpse: as the earth is moved from beneath, and the surrounding rampart increases in height, the bird sinks.

After incessant labour for about three hours, the beetle emerges, crawls upon the bird, and takes a survey of his work. If the female is on the bird, she is driven away by the male, who does not choose to be intruded on during the important business. The male beetle then remains for about an hour perfectly still; he then dismounts, dives again into the grave, and pulls the bird down by the feathers for about half an hour, and then, after three or four hours' more labour at digging, again comes up to rest. When sufficiently recruited, he rouses himself, adjusts the bird firmly into its grave, pulls it by the feathers this way and that, and having settled it to his mind, begins to shovel in the earth, which he effects in a very short time by means of his broad head, pushing the rampart of earth into the grave with amazing strength and dexterity. After the grave is thus filled up, the earth is trodden in, and undergoes a keen scrutiny all round, the bird being completely hidden: the beetle then makes a hole in the still loose earth, and having buried the bird and his own bride, next buries himself.

The female next proceeds to lay her eggs in the carcase of the bird, in number proportioned to its size, and the pair having eaten as much of the tempting viand as they please, make their way out, and fly away.

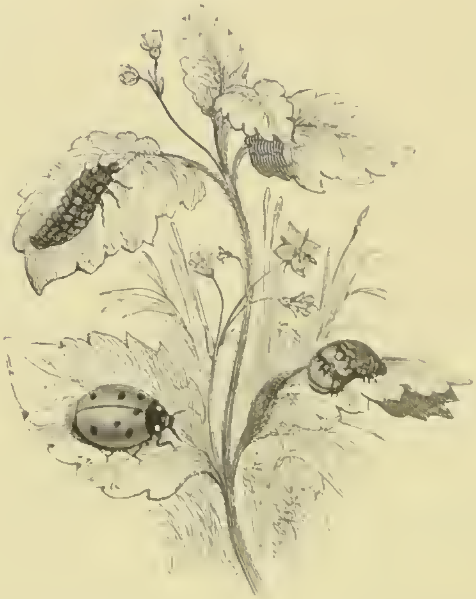
The eggs are hatched in the course of a couple of days, and produce fat scaly grubs, which grow excessively fast, and very soon consume all that their parents had left. As soon as they are full-grown, they cease eating, and burrowing further into the earth become pupæ. The length of time they remain in this state appears to be uncertain, but when arrived at their perfect state, they make round holes in the ground, and issue forth to commence elsewhere the work of inhumation.

Let us now turn our attention to the vegetable world, and we shall soon perceive equally convincing proofs of the close relationships that are established between all departments of the organized creation. Seasons return, and every plant at its appointed time renews its verdure, buds, and puts forth leaves, then flowers, and opens to the sun its glowing charms; autumn arrives, and each herb, bearing seed after its kind, scatters abroad abundant store of various food, and, having thus fulfilled its round of duties, withers and decays. At different seasons, therefore, every plant affords a different kind of food, and thus calls forth a new race of devourers; and moreover, each particular plant possessing qualities peculiar to itself, invites the taste or suits the appetite of certain species of insects, which are in their turn, by their structure and instincts, especially adapted to avail themselves of the provision thus afforded. To do more than glance at such an extensive scene as thus presents itself for our contemplation would be beyond our present purpose, still we may be permitted to select a few examples by way of illustrating this part of our subject.

No sooner do the plants put forth their tender twigs, the firstlings of the spring, than, starting into sudden life, innumerable hosts of aphides or plant-lice congregate upon the new-born shoots in such prodigious multitudes that like a blight they threaten to destroy the trees, and not unfrequently do serious injury in spite of all the efforts of the hop-grower or horticulturist. Foremost among the gardener's friends in this contingency stand forth the "lady-birds," or "lady-cows" as they are called by children, the *Coccinellæ* of the entomologist.

Innocent and harmless as they seem, these lady-birds are from their very birth the implacable and unrelenting destroyers of the aphides, in the midst of whose closely packed legions their larvæ are usually to be met with, slaughtering their ranks like wolves amongst a flock of sheep. The larvæ of these destroyers (fig. 32), like those of the water-beetles, are strong and active, of a flattened shape, and furnished with six well-formed legs, with which they range about amidst the ranks of their sluggish prey, causing prodigious havoc.

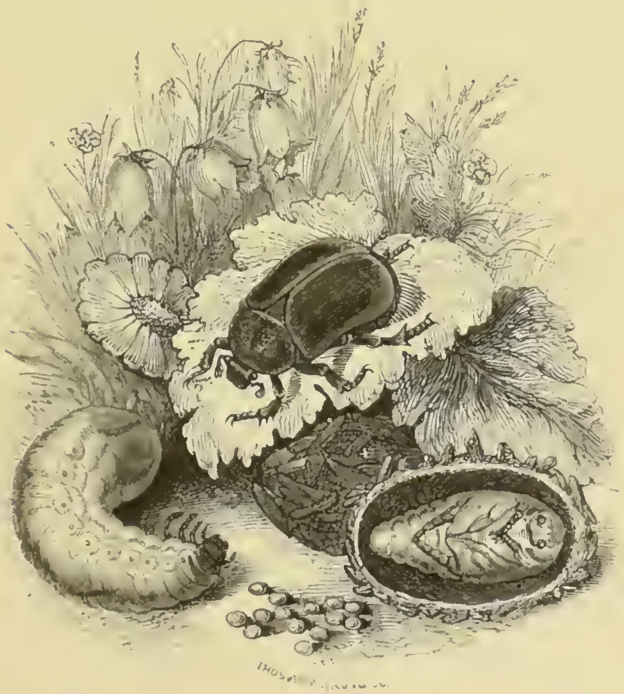
Fig. 32.



When its larvæ probation has been accomplished, the young coccinella prepares to become a pupa—it, however, spins no cocoon for this purpose, but simply fastening its tail to a leaf of the plant which it frequents, it proceeds to strip off its old skin from the fore part of its body, as shown on the right hand side of the figure, and in this condition it awaits its last change, when by throwing off its larva-skin entirely, and stripping the pupa-sheaths from its limbs, it displays the beautiful and well-known spotted elytra of the imago.

The summer comes, the opening flowers expand, and the bright sun calls forth the gayest of the insect tribes. Among the rest, in holiday attire, appear the flower-frequenting beetles, dressed as in burnished gold and gemmed with precious stones. It is, however, only in tropical countries, where the sun "showers triple light," that they appear in all their splendour; still our gardens boast a few which, like the rose-chafer, whose metamorphoses are shown in the appended woodcut (fig. 33) glean from flowers

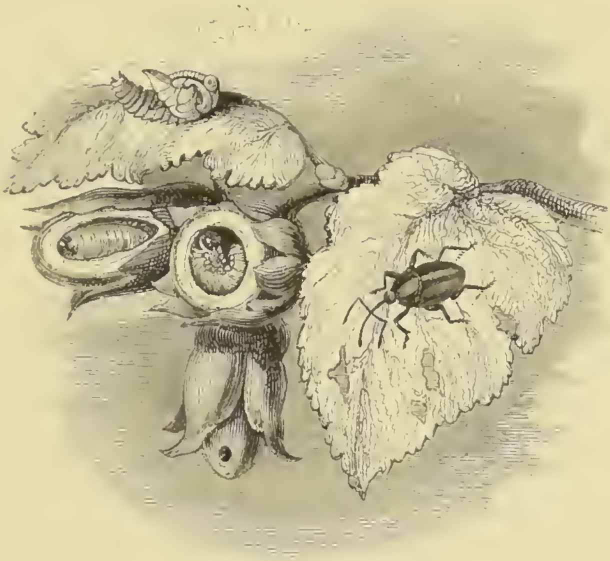
Fig. 33.



their nectar and their pollen, and adorn the drawing-room of Nature.

Autumn arrives, the time of fruits and seeds, and now appear, each at its proper season, countless hungry forms to claim their share of the abundant harvest. From the soft and mellow apple to the grains of corn, from the thin-coated acorn to the stone hard kernel of the date, the produce of each plant appears to be devoted to the sustenance of some appropriate devourer. Of this we have a remarkable proof in the case of the "snout-beetles" or weevils (*Rhincophora*), some of which exhibit instincts as wonderful as any that are conferred even upon the insect races. Every one has met with the white fleshy grub, so commonly found in ripe nuts, and perhaps, some, ignorant of its history, may have been not a little puzzled to understand how it was ever able to obtain admittance into such comfortable quarters, affording it at once an abundant supply of food and a safe domicile. This grub is the progeny of the beautiful brown beetle represented in the accompanying figure (fig. 34), which, while the envelope of the nut was young and tender, taught by an admirable instinct, drilled a hole through the soft shell in which it laid an egg and left it to its fate. Nut after nut is visited in quick succession, and an egg deposited in each, until the parent insect has exhausted all her stock. The nut expands, the shell grows hard, the kernel in due time begins to swell, and then the egg is hatched, producing the soft grub delineated in the drawing. The worm-like larvæ being shut up in a close prison have no need of limbs, and so, instead of legs, are furnished with mere fleshy tubercles; the head, however, is horny, and the mouth, strong-jawed, so that the creature leads an easy life, feasting luxuriously upon the farinaceous food in which it lives. But here we must remark another instance of that blind precaution, which the naturalist so often wonders at, but cannot ever comprehend; the grub, though working in the dark, and, albeit, unskilled in vegetable physiology, carefully avoids those vital structures of the nut, which, if destroyed, would stop the expansion of the kernel, and cut off the hopes of food. The larva thus contentedly lives on until full grown, when all its store of provender being eaten, it bores through the nut-shell with its horny jaws, and falling to the ground, there exca-

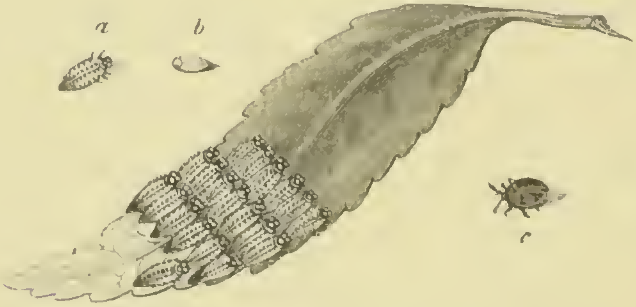
Fig. 34.



vates a subterranean cavern where it lies concealed till the beginning of the next summer. It then changes to a chrysalis such as is represented, lying upon the upper leaf of the figure, and at the proper season comes forth in full guise, and ready to set out in search of nuts wherein to plant its offspring.

But nuts and fruits form but a scanty portion of the food of devouring weevils; many of the parent beetles bore the leaves, bark, buds, the soft and juicy stems, and even the solid wood, selecting such localities as best will suit their hungry progeny. Indeed the whole vegetable kingdom seems sooner or later to be given up to the voracity of these and similar marauders. Hosts of beetles are appointed to devour the foliage in every stage of growth, and very serious consequences not unfrequently result from the ravages of such insatiable destroyers, among the most formidable of which may be mentioned the redoubtable "turnip-fly" (*Haltica nemorum*), which sometimes devastates whole districts of turnip-land, by eating the young plants as soon as they spring up. Some races attack the leaves in

Fig. 35.



regular phalanx, collecting the soft, pulpy nutriment which they afford, as carefully as reapers gather their corn upon the harvest field (fig. 35), marching forward in line, three deep, as though to take care that nothing shall be left behind their desolating array.

Whilst such as these devour the green pulp of the leaves, others of kindred habit prefer the soft alburnum, situated between the bark and the wood, sometimes destroying whole forests by their silent and unseen depredations. Others, again, live on the pith of trees, in which they excavate long galleries, while some devour the wood itself, however

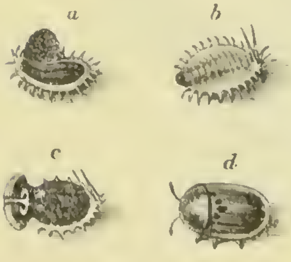
Fig. 36.

hard, and do not even respect our household furniture, as may be testified by many an antique chair and bedstead. The larvæ that thus inhabit wood are furnished with thick, horny heads and powerful jaws, with which they mine their way, forming long winding galleries, wherein they pass their pupa-state, concealed from observation, until being furnished with wings, they break forth from their hiding-places, having had the precaution, before changing into pupæ, to continue boring until close to the surface of the wood, leaving only a thin partition through which the perfect insect easily escapes.

But chiefly where decay proclaims the task of Nature ended, may be seen the busy crowds of scavengers, in beetle-form, clearing away all rottenness and filth — no stain remains; the vegetation, that has served to clothe a world, all disappears, melts like a summer cloud, and scarcely leaves behind more trace of having ever been.

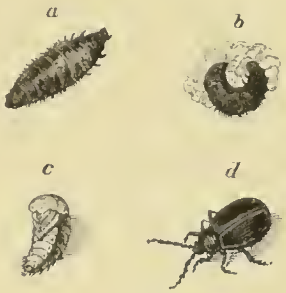
The *Cassididæ* (fig. 37), a race of beetles which feed on thistles and other plants, likewise present some remarkable peculiarities of structure. The larva (fig. 37, *b*) carries upon its tail an upright fork, upon which it usually heaps a quantity of dirt, that serves it as a parasol both for shelter and concealment, as represented in the figure at *a*. In its pupa-state it has a still more singular appearance, for, by only partially stripping off its larva-investments, *Cassida viridis* (*c*), it loses the

Fig. 37.



use of these forks, but continues to wear its old skin, like a pair of trousers, from which the anterior part of the body projects in the shape of a broad dilated hood, whereof no trace existed in its preceding condition. Lastly, casting off these uncouth habiliments, it presents itself under the shape of a pretty green beetle (*d*).

Fig. 38.



The *Chrysomelidæ* (fig. 38), and innumerable species of small beetles similar in form, find their appropriate residence upon the leaves and flowers of trees and shrubs, nay, almost every plant, from the tall forest oaks and mountain pines to the rude fungus, has its fit inhabitants selected from their races; every clime, indeed, presents us different kinds, distributed as widely as the realm of vegetation spreads, superadding life and happiness to all the beauties of fair Flora's kingdom.

CHAPTER VII.

EARWIGS, COCKROACHES, LEAF-INSECTS, GRASSHOPPERS, CRICKETS, AND LOCUSTS,—THEIR HISTORY AND METAMORPHOSES.

VERY nearly allied to the beetles, in their outward appearance, are those well-known pests of our gardens, the EARWIGS, so called from a widely-spread belief that these insects creep into the ears (*Ohr-weg*, Germ.) of sleeping persons; and dreadful tales are whispered about of the atrocities they have in this way been guilty of. The truth is, that, being nocturnal in their habits, they carefully avoid the light, and, during the day, are glad to escape from observation into any hole they can find, be it a flower-bell or a hollow stick, or any other lurking-place; and if, in their alarm, they sometimes have mistaken a sleeper's ear for a snug retreat, their intentions in so doing are by no means felonious, seeing that they possess no "leprous distilment," or other means of doing mischief.

In its imago state, the earwig possesses four wings, of which the outer pair very closely resemble the wing-covers (*elytra*) of the short-winged beetles; but the inner pair, which alone are useful in flight, present a structure so peculiar, that these insects have been named from the circumstance, EUPLEXOPTERA, the beautifully-folded wings.

On examining an earwig with its flying wings expanded, it seems indeed astonishing that they could ever be packed up into so small a space as to be hidden by the little wing-covers; nevertheless this is effected in a beautiful and simple manner.—The wing itself is of very delicate texture, and when spread out, its expansion is maintained by means of an exquisitely-constructed framework, that radiates from the centre (fig. 39), and is capable of being folded up like the bars of a fan, or rather like those circular silken screens in general use to shade the eyes when reading. From this arrangement, the wing is capable of being first closed longitudinally, after the manner of a fan, and then twice folded in a transverse direction, being thus neatly packed, like a gauze handkerchief, into the smallest possible compass. This proceeding, as may be supposed, requires very delicate manipulation on the part of the insect; and the earwig is frequently observed to employ the forceps at its tail, in adjusting the folds, or assisting in the display of its wings.

The mouth of these insects is, in all stages of their growth, furnished with strong cutting jaws, with which they devour the petals of flowers, and also attack fruits of various kinds; they are, moreover, by no means careful to avoid the choice specimens, the pride of the horticulturist; so that, when numerous, their presence in a garden is far from desirable.

The earwigs lay their eggs in the earth, or under stones, during the spring or early summer months. Their larvæ, unlike those of the beetles, exactly resemble their parents, except in size, and in the circumstance of their not possessing either wings or wing-covers. The pupæ are distinguished by their rudimentary wings, enclosed in little cases, formed

Fig. 39.

by the pupa covering; and it is only when this last integument is thrown off, that they assume their full dimensions, and become capable of flight.

The female earwigs are remarkable for their attention to their offspring; the care of the mother not only superintending the hatching of her eggs, but the young ones, we are told, run after her wherever she moves, and she continues to watch and brood over them for many days, with the tenderest solicitude.

Still more remarkable for their voracity, and formidable from their numbers, are the ORTHOPTEROUS races of the insect world; distinguished from all others by the peculiar texture of their wings. The outer pair is constructed of tough, parchment-like membrane, thickly veined, and not at all serviceable in flight; while the hinder pair, which are, when not in use, folded up beneath the former, constitute, when expanded, "sail-broad vans," enabling these marauders to sweep along,

> "Incumbent on the dusky air,"

in countless legions, famine and pestilence close following in their track. Of the numerous tribes of these insects, the most interesting, because the most formidable, are the locusts, the very name* of which impresses us with terrible associations. Fortunately, in our own country we have little cause to fear these ravagers; our crickets and our grasshoppers being rather looked upon as merry little friends than regarded as objects calculated to occasion anxiety or alarm; but in less favoured regions, as, for example, in southern Europe, and more especially in Asia, where the migratory locust swarms, they are, with too much justice, looked upon as ministers of vengeance sent from Heaven; the sky is darkened with their passing hosts, and the most verdant spots, when they alight, at once assume the appearance of a barren wilderness; even their destruction is itself a source of danger, the air for miles being rendered pestilent by the effluvia from their putrefying carcases.

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* The word *locust* is deduced from *locus ustus,* a burnt-up region, indicating the effects caused by their ravages.

Numerous and horrifying are the accounts given by writers in every century, relative to the devastation produced by these insect armies, many of them only inferior in extent to that vast host, the first of which we have any record,

> "That o'er the realm of impious Pharaoh hung
> Like night, and darkened all the land of Nile."

Highly graphic is the account given of their ravages by the sacred historian. "They covered the face of the whole earth, so that the land was darkened, and they did eat every herb of the land and all the fruit of the trees which the hail had left, and there remained not any green thing in the trees or in the herbs of the field throughout all the land of Egypt;" a description that will equally apply to the locust swarms of the present day.

M. Kohl, in his account of the provinces lying between the Black and the Caspian Seas, informs us that the farmers and agriculturists of those districts, prompted by a just dread of these terrible visitations, have established a kind of *Locust-police.* Whoever first sees a swarm approaching is bound to raise an immediate alarm, and to give the earliest possible information to the chief person of the village. Orders are then given, and every man, woman, and child comes forth, armed with bells, tin kettles, guns, pistols, drums, whips, and whatever other noisy instruments they can lay their hands on. A frightful din is then raised, which often has the effect of scaring away the swarm.

The locusts have a dread of smoke as well as of noise, and the peasants sometimes take advantage of this circumstance to smoke them away. They get together, on the first appearance of their enemy, as much straw, vine branches, or any other combustibles as they can, and light fires with these about the fields and grounds which it is thought most desirable to protect. This expedient is, however, often a complete failure, for when one of these countless swarms has dropped upon the ground, and proceeds grazing along in the direction of the fire, the mere weight of the general mass forces their foremost ranks into the fire, where, perhaps, a few thousands of them perish, but their bodies extinguish the flames, and leave a free field for the advancing enemy.

Fig. 40.

Whenever, in the line of their flight, the locusts meet with a village, they always settle down upon it and devour all that comes in their way; the roofs of the houses, the floor, and every inch of ground, are soon covered with the hissing, buzzing, and crawling vermin. During the locust-years at Odessa, the swarms covered the streets and public places, dropping by hundreds into the kettles and saucepans in the kitchens, and invading alike the ball-room, the granary, the boudoir, and the hovel. The young locusts crawl until their wings are developed, and in their march they will overcome most obstacles. They climb over the roofs of low houses, over fences and walls, march through the streets of towns and villages, not avoiding either man or beast, so that the wheels of a cart will at times sink several inches deep into a mass of locusts, while a pedestrian, walking through them, will often have them above his ancles. A swarm of young locusts, unable to fly, is more dreaded than one of older insects, for it is in vain to think of driving them away by noise or smoke; whichever way they escape they must still go along the ground, and if a few hundred thousands of them be killed, this avails little against the millions behind. The flying swarms of full-grown locusts appear in the steppes of Russia, chiefly about the month of August. Their flight is clumsy, and always accompanied with a rustling noise, as loud as that made by a strong wind blowing through a grove of trees. On a fine day they sometimes fly at a height of two hundred feet above the ground, while at other times they approach very near the surface. The multitude of locusts is so dense, that is, the height or depth of the heap is such, that every ray of sunshine or daylight is excluded from between them, and the ground beneath is thrown into complete shadow.

When the locusts espy a green field they descend precipitately, and, in their eagerness, they often break their wings as they alight. The peasants of southern Russia assert, that when a large cloud of locusts falls, it will cover a piece of ground four versts long by one verst broad (that is, three miles long by three-quarters of a mile broad), and in many places, the creatures will be three or four deep. Now, allowing for each insect a surface of two inches by one, and making no account of the patches where they lie three or four deep, it would follow that a small swarm, covering only one square verst, must consist of nearly a thousand millions of locusts.

The swarms above described are such as are met with in the steppes or plains of southern Russia. But Captain Basil Hall gives a narrative of a locust-plague much more fearful and destructive. His details relate, in the first instance, to Asia Minor, westward of the steppes, and, in the second instance, to Guzerat, eastward of the same district. In his second series of "Fragments of Voyages and Travels," Captain Hall states:—"Captain Beaufort, with whose interesting and delightful book on 'Caramenia' every reader of travels is familiar, told me that when he lay at Smyrna in 1811, he had an opportunity of forming a rude estimate of the magnitude of a flight of locusts which was drifting past from south to north. The consul had occasion to send a messenger in a due easterly direction to the Bashaw of Sardis, in Asia Minor, that is, in a course at right angles to the flight of the locusts. This person rode forty miles before he got clear of the moving column of these ravenous animals. It was inferred by observations made with a pocket-telescope, that the height of the column could not be less than three hundred yards, and the rate at which it passed not slower than seven miles an hour. This continued for three days and nights apparently without intermission. As these insects succeeded one another at an average distance of not more than three feet, and were about one foot apart above one another, it was computed that the lowest number of locusts in this enormous swarm must have exceeded 168,608,563,200,200."

After remarking that the mind is incapable of appreciating such numbers unless compared with some familiar standard, Captain Hall proceeds:—"Captain Beaufort determined that the locusts he saw, if formed into a heap, would have exceeded in magnitude more than a thousand and thirty times the largest pyramid of Egypt, or, if they had been placed on the ground close together in a band a mile and an eighth in width, would have encircled the globe."

Myriads of locusts appeared in Bengal about the beginning of 1810, from whence they took a north-westerly course across Upper India. It chanced that the fall of rain in the following year proved very scanty, so that the locusts easily devoured what crop of grass there was. As soon as this was accomplished, they proceeded in a body to the north-west district of Guzerat, and the neighbouring provinces. The swarm never reached so far south as Bombay, and entirely disappeared in 1812. Dreadful, however, were the consequences of this visit. Eye-witnesses of the occurrences in Guzerat state, that the multitudes of the Marwar people, whom hunger had driven into Guzerat, were seen, crowded like cattle in droves, beyond the suburbs of all the great towns, or by the road-sides, the dead and the dying together, men, women, and children, packed as it were into one mass; those who were yet alive suffering from acute diseases, brought on by hunger and want. The hourly recurrence of accumulated miseries familiarized the minds of these poor people, as well as the natives in general, to every extremity of suffering that human nature could bear. In a short time these emanations of individual feeling among themselves, which distinguished the first commencement of their sufferings, gradually abated, and the utmost indifference began to predominate. The wealthy inhabitants of Guzerat and of Bombay subscribed very largely for the relief of the starving sufferers, and opened places where they could come to receive a share of food. "It was a cruel sight," says Captain Carnac, in his account of this locust-plague, published in the "Bombay Literary Transactions," "to those possessed of sensibility, to witness the struggles when the doors were opened to apportion the victuals. Every sentiment of humanity appeared to have been lost among the crowds collected around; and it was no unusual thing to be informed that such and such a number had fallen a sacrifice to their precipitate voracity; many also, whose wants were supplied, continued to devour until the means intended for their relief, proved, in the end, their destruction. Children were often crushed to death when attending for their pittance of food, under the feet of their own parents."

As the dead bodies dropped around, it became a most serious question what to do with them. At and near the town of Baroda, the poor Marwarees died at the rate of five hundred a day; but at Ahmedabad, a large city with two hundred thousand inhabitants, one hundred thousand died from this awful visitation. "The demand for wood to burn the dead, called for the destruction of the houses. Even this was barely sufficient for the performance of the rites required by the Hindoo faith, and the half-consumed bodies on the banks of the Saburmuttee, evince at this hour (Feb. 1815, or two years and a half afterwards) to what straits the Hindoos were reduced in fulfilling the last duties to their kindred."

The locusts, as well as the crickets and grasshoppers, are musical, but the instruments upon which they play are somewhat different. They are, in fact, performers upon a curious kind of violin, from which they elicit a shrill music that must have attracted the attention of every one. Their wing-cases are hard and resonant, and form the fiddles upon which they play, their fiddlesticks being the thighs of their hind legs, which are finely serrated, so that no rosin is here necessary: thus furnished, the locusts, when inclined for a concert, resting on their four front legs, play away upon the edges of their wings with the hinder pair, and thus produce a piercing, and not disagreeable, note.

The metamorphoses to which these races of the

Orthoptera are subject, are so similar in the different families, that the same description is equally applicable to them all. Their eggs are numerous, and are for the most part deposited in the ground, either in holes bored by the aid of an ovipositor, or else in burrows inhabited by the parents. The young when hatched, exactly resemble the perfect insect, both in their form and general habits, except inasmuch as they are completely destitute both of wings and wing-covers (fig. 41) and, as a necessary consequence, are incapable of producing those sounds for which they subsequently become so remarkable. After several changes of skin, the

Fig. 41.

rudiments of wing-covers and wings appear, upon the second and third segments of the body, encased in the pupa-covering, and at length this last integument being thrown off, the insect appears complete in all its parts, full winged and limbed, and able to perpetuate its race.

The two next families of Orthopterous insects comprise some of the most remarkable genera met with in the whole class, *viz.*, the leaf-insects (*Mantidæ*), and the stick-insects (*Phasmidæ*), both of which are very common in tropical climates, although none of them are inhabitants of this country. However various in their appearance, these wonderful creatures have all been fashioned with a view to

Fig. 42.

their complete disguisement, and for this purpose nothing could be more effectual than the plan adopted. No Parisian manufacturer of artificial flowers could more successfully imitate the productions of Flora than these insects are made to counterfeit the branches and the foliage of the shrubs they frequent, so that whilst in their natural haunts, it is next to impossible for the most practised eye to distinguish them.

The appearance of the *mantidæ*, or leaf-insects, whilst lying in wait for prey, is very singular. They sit for hours together stationary, in the attitude represented in the annexed figure (fig. 42), with the front part of the thorax elevated, and the fore-legs held up together like a pair of arms, prepared to seize any insect which may come within their reach. It is hence that they have attained a sort of sacred character amongst the superstitious inhabitants of the countries in which they are found, and who from a fanciful notion that the insects are in that attitude engaged in prayer, have given them names indicative of their devotion, such as *Prega Diou*, *Prie Dieu*, *Louva Dios*, &c.; hence, likewise, the specific names of mantis *religiosa*, *precaria*, *sancta*, *oratoria*, &c., have been applied to them. Their attitude being that of begging, has also induced the application of such names as *mendica*, *pauperata*, *superstitiosa*. The monkish legends tell us that St. Francis Xavier seeing a mantis walking along in its solemn way, holding up its two fore legs, as in the act of devotion, desired it to sing the praises of God, whereupon the insect carolled forth a fine canticle.* Mouffet also informs us that, "so divine a creature is this esteemed, that if a childe ask the way to such a place, she will stretch out one of her feet and show him the right way, and seldom or never misse. As she resembleth those divines in the elevation of her hands, so also in likenesse of motion, for they do not sport themselves as others do, nor leap, nor play; but walking softly, she retains her modesty, and shows forth a kind of mature gravity." "But this gravity," observes Mr. Westwood, "has an object of a very different kind to that of the sorcerer; it is thus after exhibiting a wonderful degree of patience, that, like a cat approaching a mouse, the mantis moves almost imperceptibly along, and steals towards its prey, fearful of putting it to flight. When sufficiently near, the fore-leg is extended to its full length and the victim seized, being immediately secured between the tibia and the femur, where it is held by the numerous teeth with which these parts are armed."

"These insects are, in fact, very voracious: Roësel kept several for a long time, feeding them upon flies, the female devouring six in a day. When confined together they fought violently, cutting at each other with their fore-legs, and even the male occasionally fell a victim to the voracity of his partner. Roësel observes that in their mutual conflicts their manœuvres very much resemble those of hussars fighting with sabres; and the Chinese, aware of their savage pugnacious propensities, keep these insects in Bamboo cages, and match them together in combats, as is done with fighting-cocks. They are, however, as cowardly as barbarous, for the instant that Roësel introduced some ants amongst them, they endeavoured to escape in every direction."*

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* Insect Architecture, p. 63.

The mantis, lays its eggs enclosed in a membranous envelope something resembling the pod of a pea, in which they are closely packed in numerous layers, and each lodged in a separate cell. In this condition they remain for several months before the young are ready to escape. As the eggs ripen they are protruded through the thick substance of the common envelope, preparatory to the escape of the young insect. On issuing from the egg the larva has precisely the same form as the parent mantis, only it is quite destitute of wings. After changing its skin several times, the wing-covers and wings become apparent, but each as yet enclosed in a distinct sheath—this condition represents the pupa state of the insect. At length the pupa skin being likewise cast off, the wings are fully revealed, and the perfect form is at length attained.

Equally remarkable with the mantis tribes, and obviously constructed with the same purpose of concealment whilst occupying the stations appointed to them by nature, are the PHASMIDÆ, or STICK-INSECTS (fig. 43), called also walking-sticks, walking-leaves, spectres, devil's coachhorses, &c., by the inhabitants of the countries in which they are common. These, like the Mantidæ, are so fashioned as to represent, with the utmost exactness, portions of the vegetable structures amongst which they are found, and the most practised eye might fail to distinguish them among surrounding objects, so exquisitely do they correspond with them, both in form, substance, and texture. Some represent green leaves, others those that are dry and withered; many species might be mistaken for a sprig broken off a bough, whilst others, from their close resemblance to dried sticks, might easily be seized hold of by the unwary, without exciting the slightest suspicion that they were living insects. But, although both the Mantidæ and the Phasmidæ are thus similarly designed to imitate the products of the vegetable kingdom, and that evidently with a view to the same end, namely, concealment, the habits of the two families are widely different. The carnivorous mantis, armed with its scythe-like fore-legs, is disguised in order that it may steal unsuspected upon its insect-prey, and thus satisfy its blood-thirsty

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* Westwood, op. cit. vol. i. p. 448.

Fig. 43.

appetite, but the Phasmidæ are entirely restricted to vegetable diet, living altogether upon the sticks and foliage with which they are surrounded, so that the masquerade dresses in which they are clad only constitute a means of passive defence, by enabling them to escape the vigilant observation of their enemies. This difference in the habits of the two races is at once clearly seen on comparing the construction of their legs—the raptorial fore-legs of the mantis are replaced in the Phasmidæ by others of ordinary form, which are comparatively feeble, and adapted only for walking, or rather crawling slowly amongst the branches of low shrubs, upon the young and tender shoots of which they feed. The legs, indeed, are so fashioned as materially to aid in the deception; in one genus (*Phyllium*) they themselves are ornamented with leaf-like appendages, while in the dried stick-insects they look exactly like lateral off-shoots from the central withered stem, circumstances which, in conjunction with the insect's habit of remaining for a length of time motionless in the same spot, render the deception complete.

The Phasmidæ lay their eggs singly, each egg being of large size, and furnished with a little lid at the end, which opens to allow the included young to escape. The larvæ of such species as have wings do not differ from the parent, except in the want of those organs. In the pupa state the wings and wing-covers are encased in tegumentary sheaths.

The next family of this important group (BLATTIDÆ) comprises the well-known COCKROACHES, or, as they are commonly, but improperly, called "black-beetles" (fig. 44), the pests of our kitchens, and the ravagers of our larders. "These insects are nocturnal in their habits, hiding themselves during the day in holes and crevices, behind the wainscot of rooms, and in other similar places of concealment. They also appear to be fond of heat, being generally found in the greatest profusion near fire-places, and especially harbouring about baker's ovens, where they have the additional inducement of a constant supply of crumbs and other food; but nothing eatable comes amiss to them; they devour flour, bread, meat, cheese, woollen clothes, and even shoes. The ravages of these insects on board of ship is sometimes so great that barrels of rice, corn, and other provisions are completely destroyed by them, and in calm weather it is not unusual to employ boys in collecting them at a trifle per score. It is, however, in the tropics that their depredations are the most extensive. They devour all kinds of provisions, dressed and undressed, and damage all sorts of clothing, leather, books, papers, &c., which, if they do not destroy, at least they spoil. They swarm by millions in old houses, making every part filthy beyond description. They have also the power of making a noise like a sharp knocking of the knuckle upon the wainscoting. *Blatta gigantea* being thence known in the West Indies by the name of 'the

Fig. 44.

drummer;' and this they keep up, replying to each other through the night: moreover, they attack sleeping persons, and will even eat the extremities of the dead."

Such is Mr. Westwood's history of these formidable marauders, the details of which are quite sufficient to attach interest to their history.

The numerical strength of the formidable armies in which these devastators carry on their depredations is not so much owing to any remarkable fecundity on their parts, but must rather be accounted for by the inaccessible nature of their places of concealment, and their nocturnal habits, whereby they are protected from the attacks of enemies that would otherwise destroy them. Their eggs, moreover, are defended by a remarkable contrivance, whereby their preservation is ensured in a very wonderful manner. Instead of being laid separately, the eggs are, when deposited, enclosed in a horny case, or capsule, variable in its form in different species, but generally of a more or less compressed oval shape, resembling a small bean. There is a longitudinal slit in the margin of the capsule, each side of which is defended by a narrow serrated plate, fitting closely to its fellow. The inside of this egg-case is divided into two spaces, in each of which is a row of separate compartments, every one enclosing an egg, so that the whole resembles the pod of some leguminous vegetable. This capsule, with its precious contents, is constantly carried about by the female for a week or a fortnight, and is then fastened, by means of a glutinous fluid, in some safe locality. The slit of the capsule is strongly coated with cement, so as to be even stronger than the other parts. In this capsule the young larvæ are hatched, and immediately discharge a fluid which softens the cement, and enables them to push open the slit, through which they escape; after their exit the slit shuts again so closely that it appears as entire as before. In some species it would seem that the females themselves liberate their offspring by seizing the capsule when the larvæ are fit for escape, and tearing it with the aid of their fore-legs from end to end, by which means the inclosed larvæ are set at liberty.

CHAPTER VIII.

HOMOPTEROUS INSECTS.—APHIDES, LANTERN-FLIES, FROG-HOPPERS, PSYLLÆ, OR BLIGHT-FLIES. — COCCI, OR COCCHINEAL INSECTS. CICADÆ, ETC.

In the economy of Nature nothing that can be employed as a material of food is permitted to be wasted. The reader has already had abundant evidence of this great fact in preceding pages, and proofs of the truth of the assertion will continue to multiply as we proceed. With what care have we not already seen insects appointed to devour all vegetable substances, armed with strong hungry jaws, of every shape, wherewith to cut, and bruise, and file, and grind roots, leaves, fruits, wood, bark, and all the solid parts of every tree and shrub? Yet still we find a province left unoccupied, an ample store of healthy nutriment untasted, unemployed as food. Rich streams of honied sap and vegetable juices flow unseen in divers plants — Flora's pure nectar, which invites the taste of harmless races, destined to imbibe such simple beverage, and furnished with long beaks adapted well to tap the sluices where such sweets are found.

The mouth appointed for this purpose is of a very peculiar construction, and is called by entomologists a "promuscis:" it consists of a long, grooved instrument, formed by elongating the lower lip, which in some species is lengthened out until it is as long or longer, than the insect's body. In the groove of this strange beak are lodged four powerful piercers, which, when taking food, are plunged into the tender shoots, and other fleshy portions of such plants as yield the appropriate nutriment, and form a kind of pump through which the nectar is sucked up.

Among the insects thus constructed, we must first remark the *Aphides*, or Plant-lice, as they are very generally called, the latter name indeed, seeing their parasitic habits, being by no means inappropriate. Who has not observed that at certain seasons of the year the tender twigs of every rose-tree swarm with hosts of little greenish flies, some winged, and others wingless, covering the stem and buds in countless multitudes, and doing serious injury to the plants. But turning from the rose-tree the naturalist soon perceives that every fruit-tree in his garden is infested by legions equally numerous, which, although evidently allied in shape and habits, are nevertheless all different from each other, and, extending his researches still further, he is not long in discovering that almost every kind of plant seems to afford nourishment to a race of aphides peculiar to itself, and consequently, that the number of species of these aphides is incalculable. Indeed it has been ascertained that different parts of a tree yield sustenance to different tribes of these insects, and that in many cases the leaves, the bark, the fruit, the roots, and even the decaying stems, have all appropriate inhabitants peculiar to themselves. Truly the more closely we contemplate the productions of Nature, the more manifestly does their immensity stand revealed before us.

The sucking apparatus of the aphides consists of a proboscis made of several joints, which shut up into each other, much after the manner of a telescope, but which, when drawn out, is sometimes much longer than the entire body of the insect: it is armed at its extremity with a sharp point, which the aphis can plunge deep into the soft shoots of the plant upon which it lives, and having once anchored itself by infixing this curious organ, it has little more to do than to suck up nutriment during the

Fig. 45.

rest of its existence. Indeed, no sooner are they born than they join the ranks of their predecessors, each fixing itself with its head near the tail of the last, so that the whole community looks like a flock of sheep, having their heads all turned in the same direction.

It may naturally be supposed that the young branches upon which these insects live, suffer materially from their depredations, for not only are their juices exhausted by the insatiable trunks of their parasitical occupants, but being constantly pierced and pricked on all sides, they curl themselves up into all sorts of fantastic shapes, and soon become dry and withered. Sometimes the leaves are the principal objects of attack, and soon become corrugated into deep cells, or raised into large tumours and gall-like excrescences, in which entire families of aphides find comfortable board and lodging during the whole period of their lives.

Many races, as for example those which infest our apple-trees, and which are, unfortunately, too well known to gardeners under the name of "the American blight," are clothed with a thick covering of cottony down, but whether this grows like wool from the surface of their bodies, or as a factitious covering, adopted for the purposes of concealment or shade, has not been precisely ascertained.

The aphides, instead of laying eggs, as most other insects do, are, during the summer months, viviparous, producing their young alive, in the larva condition, and ready at once to attack the plant upon which they are destined to feed; but, on the approach of winter, they change their procedure, and begin to lay eggs, as will be explained hereafter.

One of the most remarkable peculiarities of these insects consists in the existence of two little tubes (fig. 45), inserted upon one of the hinder segments of the abdomen, through which there exudes an abundance of sweet saccharine fluid, which continually moistens the leaves of the trees upon which they live, covering them with a thin varnish of syrup, usually called "honey-dew" by those who are ignorant of the source whence it proceeds, a mistake which is easily pardonable, seeing that the trees of a whole district are not unfrequently covered with this honeyed secretion.

A very close relationship has long been known to exist between the aphides and the ants, but the nature of the association between them has been very generally misinterpreted by early naturalists, and is still not generally understood. Old Goëdaert, whose remarks are generally very exact, gravely affirms that these insects are the progeny of the ants, and, in describing the history of their courtship, gives us specimens of imaginary love ditties, supposed to pass between these most incongruous couples. Even at the present day similar ideas are prevalent among the lower classes, for when once an erroneous notion has been promulgated by authority, nothing is more difficult than to eradicate it from the minds of the ignorant, more especially if it tallies at all with their limited observations. That a warm attachment is manifested between the ants and the aphides there can be no doubt, but this, at least on the part of the former, is of a very interested character; in fact, it is as pure an example of what has been sometimes called "cupboard love" as can possibly be adduced. It is not the aphides that the ants are fond of, but the sugared fluid that the latter secrete; and it would seem that from this source they derive an important addition to their daily fare, not inaptly comparable to the milk obtained by man from the cows kept in his pastures. The ant ascends the trees, says Linnæus, *that it may milk its cows, the aphides;* and its proceedings amongst its cattle, which may be easily watched by any attentive observer, have been thus graphically described.* The aphides, when no ants attend them, waste the sweet fluid which they produce, and, by a certain jerk of the body, which takes place at regular intervals, they ejaculate it to a distance; but when the ants are at hand, watching the moment when the aphides emit their fluid, they seize and suck it down immediately. This, however, is the least of their talents, for they absolutely possess the art of making them yield it at pleasure; or, in other words, of milking them. On this occasion, their antennæ are their fingers; with these they pat the abdomen of the aphis on each side alternately, moving them very briskly till a little drop of the honeyed fluid appears, which the ant immediately takes into its mouth and swallows. But this is not the most singular part of the history. "Ants make a *property* of these cows, for the possession of which they contend with great earnestness, and use every means to keep them to themselves. Sometimes they seem to claim a right to the aphides that inhabit the branches of a tree, or the stalks of a plant; and if stranger-ants attempt to share their treasure with them, they endeavour to drive them away, and may be seen running about in a great bustle, and exhibiting every symptom of inquietude and anger. Sometimes, to rescue them from their rivals, they take their aphides in their mouths; they generally keep guard around them, and, when the branch is conveniently situated, have recourse to an expedient still more effectual to keep off interlopers. They enclose it in a tube of earth and other materials, and thus confine them in a kind of paddock near their nest, and sometimes communicating with it.

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* Kirby and Spence, vol. ii. p. 88.

"One species, common in our meadows, the yellow ant (*Formica flava*), which is not fond of roaming from home, and likes to have all its conveniences within reach, usually collects in its nest a large herd of a kind of aphis that derives its nutriment from the roots of grass and other plants (*Aphis radicum*). These it transports from the neighbouring roots, probably by subterranean galleries excavated for the purpose, leading from the nest in all directions; and thus, without going out, it has always at hand a copious supply of food."

The aphides, indeed, share the care and solicitude of the ants equally with their own offspring, the latter taking every care of their eggs, and tending them as assiduously in all respects as a farmer would his lambs or his young cattle.

Perhaps the most remarkable circumstance, however, still remains to be told. Throughout all the spring and summer months, however great may be the number of these insects, they are all females; and though some of them are furnished with wings, the majority remain perfectly wingless. Nevertheless the latter are equally prolific with the former, and their progeny not unfrequently ultimately assume the winged state. To the superficial observer, it would seem that the aphides actually lay eggs whilst in their larva condition, which would indeed be an anomaly unparalleled in the insect world. Closer examination, however, reveals the real nature of so strange an aberration from the usual proceedings of Nature. The great majority of the aphides never have occasion to leave the twig where they were first produced, from which they derive their nourishment, and on which their progeny are destined to pass their lives; so that, to creatures thus circumstanced, wings would be entirely useless; consequently these organs are not given; and although the insects undergo all the usual changes of skin, they never assume the complete imago form. Yet, to other members of the family, the privilege of possessing wings has been accorded; obviously with a view to the dispersion of the race; and thus both apterous and winged females are constantly met with in the same batch.

Another circumstance, equally wonderful, is the astounding fertility of these little insects, and the peculiar conditions under which they produce their offspring. Throughout all the spring and summer months all the aphides are females, and yet they go on giving birth to brood after brood, all of the same sex, and all equally prolific. It is at the end of the season only, just at the approach of winter, that, instead of living young, which are all females, the aphides lay a few eggs, from which those males are developed that are to be the fathers of the innumerable progeny of the ensuing year, even to the ninth or tenth generation; and seeing that the original female may still continue to have young ones when the ninth family of her descendants is capable of reproduction, it has been estimated that even at the fifth generation a single male aphis may be the great-great grandfather of nine billions nine hundred and four millions of young ones, or, in other words, of a family about fifty times more numerous than all the human inhabitants of this globe! From these data we will leave our readers to judge what might be the result of their undisturbed multiplication; for it will soon be evident that, in the course of a few months, even these despicable plant-lice would become a plague more terrible than any with which the world has been visited. Fortunately, however, even here the balance between destruction and increase is held with a steady and unwavering hand; and when we notice the innumerable enemies by which their legions are unremittingly attacked, we are almost led to wonder how any of them escape from such hosts of hungry and relentless foes.

Neither let us imagine that these humble animals have been created in such numbers, merely for the purpose of destroying vegetation, and of affording food to ants, or more voracious persecutors. Man, as we shall soon perceive, has not been forgotten in the distribution of vast races of nearly allied insects.

The *Coccidæ*, so called from the valuable Grecian dye, κοκκος, more than counterbalance, by the richness of their productions, all the devastation caused by the aphides we have been describing; and various European and Asiatic species are sources of considerable wealth to the countries where they are found.* But the discovery of the Cochineal insect of Mexico (*Coccus cacti*), which lives in immense multitudes on the *Cactus cochinellifer*, from the richness of the colour it affords (cochineal), has thrown the dyes derived from other species into the shade, and has proved one of the most productive sources of the wealth of that country. This insect is collected in such quantities that, according to Humboldt, 800,000 pounds of cochineal are annually brought to Europe, each pound containing about seventy thousand insects: and the annual consumption in England alone has been estimated at 150,000 pounds, worth £375,000 sterling.

Another species, the *Coccus lacca*, furnishes the valuable Indian product termed *lac*, an article of so much importance in the manufacture of varnishes, sealing-wax, &c.; it is also the basis of French-polish, and is used in making water-proof hats, as well as in dyeing. This substance, although its properties seem not to be very different from those of the juices of the trees upon which the insects that produce it feed, is nevertheless indisputably an *animal* secretion. The cocci which furnish it,* fix themselves to a part of the branch of the trees they frequent (*Ficus religiosa* and *indica*, *Butea frondosa*, and *Rhamnus jujuba*), when a pellucid and glutinous substance begins to exude from the margins of their bodies, and in the end covers the whole insect with a cell of this substance, which, when hardened by exposure to the air, becomes lac. So numerous are the insects, and so closely crowded together, that they often entirely cover a branch, and the groups take different shapes, as squares, hexagons, &c., according to the space left round the insect which first began to form its cell. Under these cells the females deposit their eggs, which, after a certain period, are hatched, and the young *cocci* eat their way out. In this state the resin-like substance is called *stick-lac;* when separated, pounded, and the greater part of the colouring matter extracted by water, it is *seed-lac;* when melted down into cakes, *lump-lac;* and when strained and formed into thin laminæ, *shell-lac.*

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* Westwood, Modern Classification of Insects, vol. ii. p. 448.

Another species of coccus is found upon the *Tamarix mannifera*, a large tree which grows on Mount Sinai. The female insects puncturing the young shoots with their proboscides, cause them to discharge a vast quantity of a gummy secretion (*manna*), which quickly hardens and drops from the tree, when it is collected by the natives, who regard it as being the real manna eaten by the Israelites. Other species produce in abundance a substance almost identical with white wax; and various other important proceeds of their industry might be enumerated, but we have already said enough to show that these despised vegetable parasites are by no means useless and unprofitable members of the animal creation.

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* Kirby and Spence, vol. iv. p. 142.

Equally well known, and unfortunately almost as abundant as the aphides, are the *Psyllidæ*, the pests of our orchards, and the destructive causes of what is commonly called the blight upon our fruit-trees, and various other shrubs, to each of which a different species seems to be appropriated, so that they are distinguished among entomologists by the names of the plants upon which they are found, as for example, *Psylla pyri*, *Ps. mali*, *Ps. urticæ*, *Ps. betulæ*, &c., respectively indicating the parasites which infest the pear-tree, the apple-tree, the nettle, and the birch. In the preparatory stages of their growth, the Psylli are generally covered with a white cottony substance, matted together with a sweet and gummy secretion, and, from the prodigious numbers in which they are produced in some seasons, are fearfully injurious to the horticulturist.

Another race, often remarkable for the variety and beauty of their colour, is very commonly met with upon plants and trees, the juices of which they suck by means of their sharp and penetrating rostrum. These are the well-known "Cuckoo-spit flies," or "Frog-hoppers," whose larvæ and pupæ cover themselves with a frothy secretion, in the middle of which they reside, defended from the rays of the sun by means of this singular protection. In some species the fluid thus poured out is strongly impregnated with saccharine materials, and is then eagerly sought after by the ants, which attend upon them as they do upon the aphides, for the sake of procuring this sugared beverage.

Fig. 46.

Many members of this group of insects are remarkable for producing in great abundance a peculiar waxy secretion, converted by the Chinese into an important article of commerce, and employed for various purposes. * The insects which furnish this remarkable production, live upon the juice of a certain tree, called in the country Tong tçin, and the wax which appears to exude from all parts of the surface of their bodies is deposited in cottony-looking floccules, or thin lamellæ, upon the branches that they frequent. The Chinese collect it at the approach of autumn, by scraping the boughs on which it is found—it is then melted and strained into cold water, when it hardens, and is made into cakes exactly resembling white wax, but of a superior quality to that furnished by bees. It is mixed with oil for domestic purposes, or made into candles, which are much esteemed in the East Indies. It is likewise employed in medicine, and looked upon as an indispensable article in the Chinese pharmacopœia.

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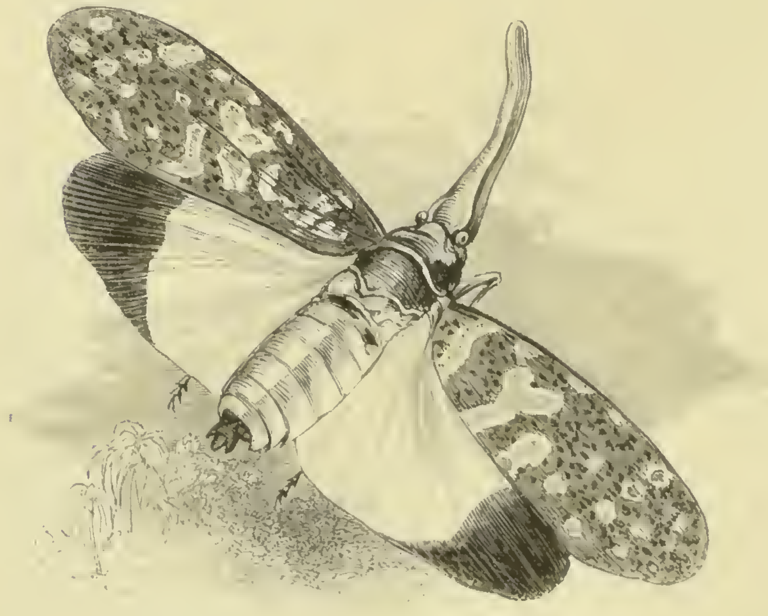
* Westwood, op. cit.

The Fulgoridæ, or lantern-flies, are likewise Homopterous insects, many of which are distinguished by the extraordinary conformation of their heads, often expanded into an enormous muzzle, varying in shape in the different species, and in some nearly equalling the rest of the body in length.

The *Fulgora laternaria* has long had the reputation of being pre-eminently endowed with the faculty of emitting a brilliant phosphorescent light, and various tales have become current relative to its supposed luminosity, some having gone so far as to assert that the Chinese ladies are in the habit of wearing these insects alive in their hair, and thus adorning themselves with living brilliants. This

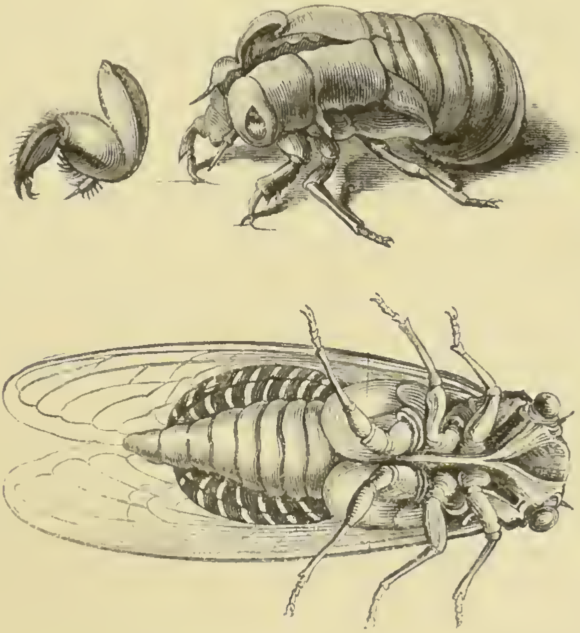
Fig. 47.



account seems to have been first promulgated by Madame Merian, in her history of the insects of Surinam; but subsequent naturalists have failed in verifying her statement, although many authors have had the opportunity of observing the Fulgoræ while alive, so that its luminous power is at present generally discredited.

Lastly, to complete our enumeration of the varied attributes conferred upon the Homopterous races, we must briefly notice the musical talents of the Cicadæ, long celebrated in the songs of the poets, and even thought worthy of notice by the muse of Anacreon. The "Cicada canora," as Virgil calls these noisy musicians, has indeed a voice sufficiently shrill to attract the attention of any one possessed of ears,

Fig. 48.



but we think that, like the cawing of the rook, it is rather by harmonizing with the grand chorus of Nature than from any peculiar sweetness in its notes, it has called forth the praise bestowed upon it.

Its instrument of music is of unique construction, and is possessed by the male insect only; it consists of two tensely stretched iridescent membranous plates, very like tambourines in appearance, situated on each side of the first segments of the abdomen, and carefully protected from injury by a pair of broad horny plates, resembling shutters. A powerful muscular apparatus is connected with this strange organ, and produces the shrill stridulous sounds, but by what mechanism is still a matter of speculation.

These insects, like the preceding, live upon trees, the juices of which they suck, and although in Europe they may be esteemed a harmless race, in some countries, where at certain seasons they abound to a prodigious extent, they become very formidable visitants. Thus, in some parts of the United States, about the month of June, the oak forests are crowded with millions of these noisy insects. "Here such immense numbers are sometimes congregated as to bend, and even break down, the limbs of the trees by their weight, and the woods resound with the din of their discordant drums from morn to eve. After pairing, the females proceed to prepare a nest for the reception of their eggs. They select for this purpose branches of a moderate size, which they clasp on both sides with their legs, and then bending down their piercer (ovipositor) at an angle of about forty-five degrees, they repeatedly thrust it obliquely into the bark and wood in the direction of the fibres, at the same time putting in motion the lateral saws, and in this way detach little splinters of the wood at one end, so as to form a kind of fibrous lid or cover to the perforation. The hole is bored obliquely to the pith, and is gradually enlarged by a repetition of the same operation, till a longitudinal fissure is formed of sufficient extent to receive from ten to twenty eggs. The side pieces of the piercer serve as a groove to convey the eggs into the nest, where they are deposited in pairs, side by side, but separated from each other by a portion of woody fibre, and they are implanted into the limb somewhat obliquely, so that one end points upwards. When two eggs have been thus placed, the insect withdraws the piercer for a moment and then inserts it again, and drops two more eggs in a line with the first, and repeats the operation till she has filled the fissure from one end to the other, upon which she removes to a little distance, and begins to make another nest to contain two more rows of eggs. She is about fifteen minutes in preparing a single nest and filling it with eggs, but it is not unusual for her to make fifteen or twenty nests in the same limb, and one observer counted fifty nests extending along in a line, each of them containing fifteen or twenty eggs in two rows, and all of them apparently the work of one insect. After one limb is thus sufficiently stocked, the Cicada goes to another, and passes from limb to limb and from tree to tree, till her store, which consists of four or five hundred eggs, is exhausted. At length she becomes so weak by her excessive labours to provide for a succession for her kind as to falter and fall in attempting to fly, and soon dies. The punctured limbs languish and die soon after the eggs, which were placed in them are hatched, they are broken by the winds, or by their own weight, and either remain hanging by the bark alone, or fall with their withered foliage to the ground."*

The young larvæ on leaving the egg have very much the appearance of fleas, each being furnished with six feet, by the aid of which they effect their escape from their wooden cell, through an aperture left by the parent insect for the purpose. They then bury themselves in the earth, where they grow to their full size, having the form represented in the figure (fig. 48). On casting their last larva-skin, they are changed into active pupæ, in which condition they only differ from the larvæ in having rudimentary wings visible upon the sides of the thoracic segments (fig. 48). Both the larvæ and pupæ are remarkable for the extraordinary size of the fore-legs, which are very robust, and adapted both for digging and for taking a firm grasp of any foreign object. During the winter these pupæ are said to burrow to the depth of two or three feet into the earth, from which they subsequently emerge, to enter upon their winged state.

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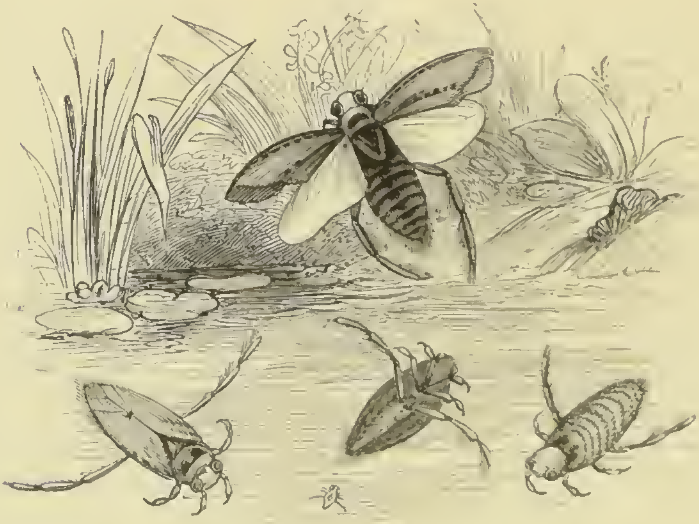
* Vide Maunder's "Treasury of Natural History," article Cicada.

CHAPTER IX.

HETEROPTEROUS INSECTS. — NOTONECTÆ OR WATER-BOATMEN. — HYDROMETER.— NEPA, OR WATER-SCORPION ; AND ON THE AMICES, OR BUGS, REDUVIUS, ETC.

Among the many situations that require to be occupied by insects of peculiar construction, few are of more importance than the surfaces of stagnant pools and ditches. Thousands of tiny creatures falling by accident into the water, perish daily in every pond, and their floating bodies offer a supply of food far too important to be neglected; it can, therefore, excite no surprise that whole tribes of insect devourers have been appointed to luxuriate on such rich pasturage as is here afforded, gorging themselves upon the carcases with which they are everywhere surrounded. Various are the agents employed upon this service. Among the most active of these are the *Notonectæ*, or water-boatmen, as they are termed, although the name of water-boats might seem a more applicable title. The whole structure of one of these insects is in accordance with the most scientific principles of boat-building; the general contour of the body, the curved and keel-like back, and the inflexed position of the head towards the breast, all combining to facilitate its movements in the element it frequents. The two anterior pairs of legs offer nothing very remarkable in their structure, being terminated by simple claws of ordinary form; but the hinder legs, which constitute their principal means of locomotion, are

Fig. 49.



metamorphosed into a pair of oars of singular beauty and remarkable efficiency, the point of their connection with the body being chosen with mathematical precision, to ensure the most effectual application of the propelling power, while the opposite extremity of the limb being bordered by a strong fringe of stiff hairs, offers a large expanse of surface wherewith to strike the water. Nothing, indeed, can be more amusing than to watch the evolutions of these living canoes whilst in their native element; sometimes in hot weather they will remain motionless at the top of the water, lying upon their oars to enjoy the sunshine, but with their long paddles fully extended, ready to be used at a moment's notice, and upon the slightest alarm, by a single stroke they dive beneath the surface, or row themselves with incredible speed beyond the reach of danger.

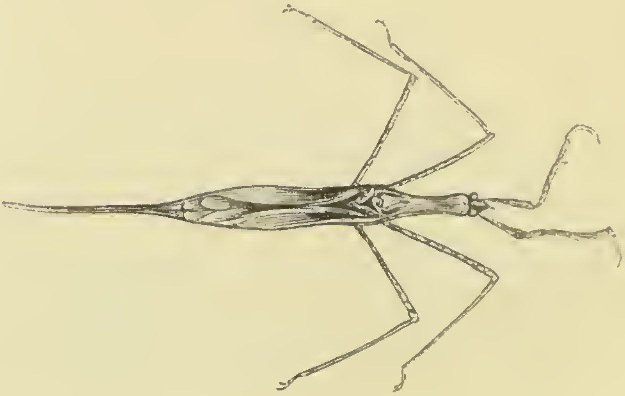
A very remarkable peculiarity is, moreover, observable in the construction of the eyes of these Notonectæ, which are each divided into two parts, one set being apparently adapted to see beneath the surface of the water, whilst the other would seem to be intended to ensure perfect vision when raised into the thinner medium of the atmosphere.

Thus equipped, the natural position of the *water-boatmen* is precisely the reverse of that of other insects, for, lying on their backs, and sailing about in this position, their avocation is to keep strict watch for any object that may fall into the water adapted to afford them suitable food, and doubtless they are seldom in want of an abundant supply.

Whilst the Notonectæ thus ply their living skiffs, working from beneath, another large family of insects, equally remarkable in their habits, assist them most efficiently in their labours. These are the *Hydrometræ* or *water-measurers,* as the name imports, which may be seen in summer time walking upon the surface of every ditch and pool of stagnant water with as much facility as if it was solid ground; ranging over the top of the pond in search of the same kind of food that the boat-like insect attacks from below, and thus sharing the abundant provision afforded in the situations they frequent.

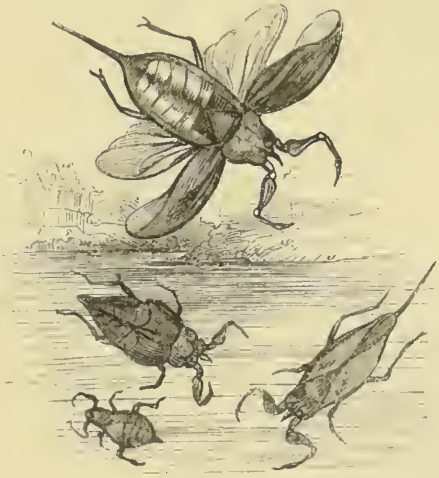
From the remarkable facility possessed by these insects of walking upon the water, we might be led to expect some peculiar structure of the foot, enabling them to perform this, to other insects, impracticable feat, and in some species certain minute membranous retractile lobes have been pointed out upon the under surface of the tarsi of the fore-legs, which may probably facilitate their movements; their chief armature, however, seems to be a close covering of thick, silky, and shining hair which invests their whole body, and repels the water as completely as the dust of lycopodium, or the feathers of a duck; it is indeed impossible to wet them, and even in a pelting shower of rain, when every drop might be thought to bring with it inevitable destruction, they may be seen skaiting along the top of the water as securely as if it was a sheet of ice, and quite regardless of the storm around them.

Fig. 50.



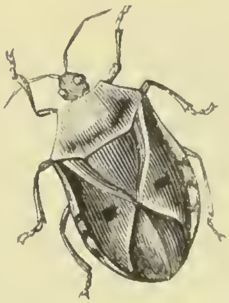
Another race of insects, very different from the Notonectidæ and Hydrometridæ, in their structure and mode of life, but equally predacious in their habits, powerfully contribute to the same result. From the peculiarity of their appearance they are commonly known by the name of *water-scorpions*, although of course they have no real affinity with scorpions, properly so called, the latter belonging, as we shall see hereafter, to a very different class of animals.

Fig. 51.



Instead of swimming at the surface of the water, the *Nepidæ* (fig. 51), crawl about the bottom, or climb the stems of sub-aquatic plants, in search of the larvæ of other insects, which they pursue with insatiable rapacity, seizing hold of them by means of their extraordinarily constructed fore-legs, and, after perforating their bodies, sucking out their nutritive juices by means of the sharp piercers which arm their beak. Their fore-legs, the instruments wherewith they grapple and hold their vainly struggling prey, while this work of butchery is perpetrated, are so strangely placed, and so singular in their appearance, that they have been mistaken by some authors for antennæ; they form together a pair of strong and robust forceps, the sharp-pointed blades of which seize the unfortunate victims with a deadly grasp, and retain a sure hold until the work of destruction is completed. In tropical climates, where certain genera belonging to this family attain to much larger dimensions than those of our own country, their attacks are by no means confined to the larvæ of aquatic insects, but frogs and other animals perish in the tenacious embrace of these formidable assailants.

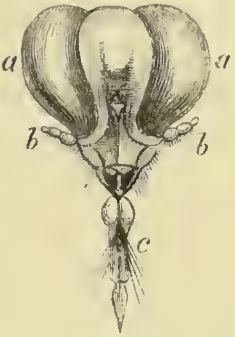
Fig. 52.



The second division of the blood-thirsty insects, usually designated "Bugs," comprehends a family very widely distributed, and includes races of remarkable beauty, exhibiting a brilliancy of colouring scarcely surpassed by the mostly richly bedizened specimens which ornament the collections of the Entomologist, although, perhaps owing to the name they bear, they are seldom regarded as inviting objects of study.

These sucking tribes are from their habits divisible into two groups, those which live upon blood and animal juices, and those which frequent plants and flowers, from which they obtain a more elegant description of nutriment by imbibing the sap and other vegetable fluids: too often, unfortunately, it is with the former only that the unscientific are familiarly acquainted, and, consequently, the execrations deserved by a few species are bestowed upon the entire race.

Fig. 53.



MOUTH OF BUG.

The *Cimex lectularius*, the common pest of the dormitory, has been generally regarded as the type of all the rest, and the "name of fear" to which its insidious attacks upon the helpless sleeper have given it a pre-eminent title, has gradually been transferred to the more beautiful and innocuous members of the group.

There is reason to suppose that the bed-bug was, at least, not common in England prior to the Great Fire in London, in 1666, after which event, as is generally believed, it was imported with the timber brought from America. Certain it is, that in the time of Shakespeare the word bug had a very different application to that which it bears at present,* being

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* In "Winter's Tale," act iii. scene 2, it is applied to *death*.

Sir, spare your breath,
The *bug*, which you would fright me with, I seek.

For Warwick was a *bug* that fear'd us all.
Henry VI. Part II. act v. scene 2.

——— Where I found, Horatio,
A royal knavery; an exact command,—
Larded with many several sorts of reasons,

then evidently used as synonymous with bug-bear, or any fearful object. Of this there is likewise an additional proof in Mathews's version of the Bible, where the passage "Thou shalt not be afraid of the *terror* by night" (Psalm xci. 5), is rendered "Thou shalt not nede to be afraid of any *bugs* by night."

Man, however, is not the only sufferer by the persecutions of these nocturnal marauders; pigeons, swallows, and, doubtless, many other birds, are infested by different species which haunt their nests, and even bats, in spite of their insectivorous appetites, are unable to defend themselves against similar blood-thirsty assailants.

But while thus engaged in causing discomfort and annoyance, it may be some satisfaction to their victims to know that these destroyers of rest are by no means secure against the attacks of other races having similar habits to themselves. Thus the *Reduvius personatus* is, in all stages of its growth, their unrelenting enemy, and by far more than a match for them at their own weapons of cunning and stealthiness. While in the larva and pupa condition, the reduvius, finding itself, on account of the slowness of its pace, unable to pursue its more active prey,

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Importing Denmark's health, and England's too,
With, ho! such *bugs* and goblins in my life,—
That, on the supervise, no leisure bated,
No, not to stay the grinding of the axe,
My head should be struck off.

Hamlet, act v. scene 2.

accomplishes by stratagem what it would be unable to effect by other means. It invests the whole of its body and limbs, which are covered with little hooklets provided for the purpose, with particles of dust, feathers, or other similar materials, until, even to a practised eye, its real character is quite undistinguishable; and, thus disguised, it gradually approaches the haunts of its unsuspecting game, and by a species of deer-stalking, peculiar to itself, at last succeeds in getting within reach of the object of its attack. Another reduvius, known in the West Indies by the name of the "wheel-bug," from the circumstance of its back being rounded and toothed like a cog-wheel, is possessed of the power of discharging an electric shock in miniature, something like that of the Torpedo, which is sufficiently powerful to startle the incautious entomologist who may chance inadvertently to lay hold of it, and is doubtless calculated to paralyze the insects upon which it feeds.

CHAPTER X.

NEUROPTEROUS INSECTS.—TERMITE ANTS.—EPHEMERON.—DRAGON FLIES, ETC.

In the Neuropterous order of insects, Termite ants first arrest our notice, whose terrible powers of destruction are the theme of every traveller in tropical countries, and, moreover, whose remarkable instincts are such as to excite the admiration of all who have an opportunity of witnessing their proceedings. The termites (for they have, strictly speaking, no claim to the name of ants) are met with in the south of Europe; but it is in the hotter regions of Asia, Africa, and America that they most abound, and that to such an extent as to become seriously mischievous to the inhabitants of those countries. These insects live together in immense societies; and as the countless members of each community co-operate in the performance of every task which their instinct leads them to undertake, and moreover, as all their labours are carried on with the utmost regularity and order, the results of their combined efforts are truly astonishing.

A colony of Termites, in full work, is found to consist of no fewer than five classes of inhabitants, to each of which special duties are appointed, and which consequently will require separate notice. These are, First, winged males; Secondly, winged females; Thirdly, soldiers, or *neuters* as they are sometimes called; Fourthly, *workers* or *larvæ;* and, Fifthly, *pupæ,* only distinguishable from the last by their possessing the rudiments of wings, which, in the larvæ condition, are of course totally wanting.

The life of the *male Termites* (fig. 54), on arriving at the winged state, is probably of very limited duration, terminating, as in the case of the hive bees, shortly after pairing with the monarch and mother of the future colony. The *female,* or queen termite, on the contrary, is destined to a lengthened period of existence, during which she is

Fig. 54.

to become the founder of a prodigious family. No sooner is the queen impregnated, than her wings, which henceforth would be useless appendages, fall off, and she is content to become a prisoner during the remainder of her life. Liberty would, indeed, be of little use to her, for in the course of a short time her size increases to such an extent that locomotion would be out of the question; her abdomen becomes distended until it resembles an enormous barrel, to which her head and trunk are only insignificant appendages, as represented in the figure (fig. 54). In this condition she must of course be fed and waited upon by labourers appointed for the purpose, who are her constant attendants. At length, having grown to twenty or thirty thousand times her original bulk, she begins to lay her eggs in incredible numbers, eighty thousand being produced in the course of twenty-four hours; and as the process of oviposition continues during several months, the numbers to which she gives birth are absolutely incalculable. Indeed, the fecundity of this insect probably surpasses that of any other creature, with the exception, perhaps, of certain fishes; and were it not that few only are permitted to become thus prolific, the locusts themselves would sink into insignificance before the innumerable hosts of these devouring multitudes, and whole continents would be rendered desolate by their ravages.

Whilst the queen Termite is thus rapidly adding to the population of the colony, the *workers* are all assiduously employed in attending to her wants, and enlarging the citadel in which she resides, so as to keep pace with the growing exigencies of the community. Herculean, indeed, are the labours of these indefatigable workmen, and gigantic the results of their industry and perseverance. Notwithstanding their diminutive size, the working termites erect edifices which challenge comparison with the proudest monuments of human architecture, nay, the most colossal structures of which man vaunts himself. St. Paul's and St. Peter's and the Pyramids themselves are but humble displays of architectural skill when compared with the habitations constructed by these apparently despicable insects. The "nests," as they are called, of the *Termes bellicosus,* described by Smeathman, are, in fact, castles, ten or twelve feet in height, and flanked with numerous conical towers or turrets, presenting a very imposing appearance. These vast edifices are entirely composed of tempered clay, and so substantially built that they are sometimes used as watch-towers whence to descry the approach of vessels at sea. Externally these edifices are covered with the grass that soon grows upon them, so as to give them the appearance of artificial mounds; but internally, each of them is a vast city, exhibiting a wonderful maze of streets and buildings, which, on careful examination, are found to be arranged with great skill and foresight. Innumerable are the galleries which lead to the different departments of this enormous edifice. The royal abode, in which the queen is lodged, surrounded by the apartments occupied by her host of attendants; the nurseries for the reception of her countless progeny; the storehouses for provisions, all display an exact adaptation to their different uses, and, as Smeathman assures us, bridges, which would seem to have been planned in accordance with the best principles of architecture, are thrown across from gallery to gallery at various points, so as to facilitate the means of intercourse. The whole of this great metropolis is built in an inconceivably short space of time, the only instruments employed are the little jaws of the working ants, the only material, well tempered clay, every particle of which must be collected at a distance, and prepared beforehand, and the only plan by which the labours of the workmen are directed, the instinct implanted in every individual of the prodigious host.

Other species of Termites construct their residences in different manners. The citadels of *T. atrox* and *T. mordax* have externally the appearance of cylinders of clay, about three-quarters of a yard high, the top of which is covered with a conical roof that projects beyond the perpendicular walls. The *T. arborum* builds a nest among the branches of lofty trees, while other species are content to dwell in holes in the ground, or in the trunks of hollow trees, which they excavate in all directions, by forming innumerable galleries : all, however, evince what wonders patient industry and combined labour are able to achieve.

Equally methodical are these white ants in the exercise of those destructive propensities which render them such formidable neighbours to the inhabitants of the districts where they abound ; indeed, their ravages seem rather the effect of magic than the results of any natural cause. A man locks up his house and goes away with the key in his pocket, leaving his property, as he thinks, quite secure from injury during his absence, and on his return, after the lapse of a few days, finds everything, apparently, just as he left it. The wooden table on which he dined stands in its usual place—his old arm-chair is found in its ordinary position—the pictures on his walls greet him with their former looks—and his chests and his packages seem undisturbed and safe. His self-gratulations at the sight are, however, but of short duration. He throws himself into his chair but perceives it is no longer the same; he catches hold of his table, and finds it but the ghost of its former self; he looks more narrowly around him, and finds that the paintings upon his walls are only the pictures of pictures, and his chests and his boxes emptied of their contents, present, alas! but a heap of rubbish to his astonished eyes, nay, even his house itself is no longer there, for the very beams and rafters are gone, although they still miraculously support what seems the original fabric. He finds in short, to his dismay, that the white ants have paid him a visit, and is astounded at the mischief they have been able to produce in so short a period.

In order to understand how all this is effected so secretly, the reader must be informed that the Termites invariably work under cover, and are particularly careful to avoid the slightest exposure to daylight. The highways leading from their nests are always arched over like long railway tunnels, and to whatever distance they may travel the same kind of arched roof is prolonged, so that they are always concealed from observation. Arrived at the objects of their attack (and nothing made of wood or vegetable fibre comes amiss to them) the same cautious system is invariably maintained: they will eat the whole of the interior of a plank, leaving no mark externally to lead to a suspicion of what is going on within—if they fancy a table or a chair for breakfast, they eat their way up the inside of the legs, until they get to the top, which they excavate in a similar manner, always leaving the surface untouched, so that nothing remains but an external shell instead of the solid mahogany. The pictures and the picture-frames, the chests and the boxes, are all devoured with the same precaution, until all the furniture upon the premises is in this way destroyed. The most remarkable part of the proceedings is, that although they thus devour the substance of the legs of tables, and even of the beams of houses, they never allow them to fall down; they seem to know too well that in such case they themselves would inevitably perish in the ruins. When, therefore, they attack a pillar or a bed-post, or anything else that supports a superincumbent weight, they are careful to replace with the hard cement with which they build, every particle of wood, as they remove it, so that although all its interior be devoured, the post or the pillar still remains solid enough, having been by this strange kind of petrefaction, transmuted from wood into stone.

Whilst the working Termites are thus employed in such various labours, the *soldiers,* who form a distinct class of the community, do not at all interfere with their operations, or in any way lend a helping hand—their duty seems to be exclusively military, and war their sole business. Their whole appearance is very different from that of the labourers from which they are at once distinguishable by their enormous heads and formidable jaws (fig. 54). In time of peace they seem to do the duty of sentinels, but in case of any attack upon their citadel, are quite ready for active service, and as their numbers are computed to be about one to every hundred labourers, they form altogether a very respectable *corps d'armée.* It is an interesting spectacle to witness the evolutions of these insect troops. Should an attack be made in their citadel by the adventurous entomologist, whose pickaxe is sometimes employed for that purpose, the peaceable citizens at once take shelter in their fastnesses, but the warlike soldiers lose no time in hastening to the breach, where their regiments soon make their appearance in battle array, threatening with angry jaws any assailant who may advance against them, and quite ready to renew the scene of Badajoz should any foes advance to storm their fortress. The danger being past, however, the assembled legions quietly disband, the terrified labourers emerge from their lurking-places, and instantly set to work to repair the damage done to their walls, toiling incessantly till this is accomplished, while the soldiers are content with leaving a few sentries to watch over them while thus employed, and to incite them to increased diligence.

As the season advances, the time approaches for the dissolution of the community, and the destruction of all the incalculable multitudes, of which, by the end of the summer, it is composed. Almost simultaneously the vast host becomes furnished with wings, and issues, like a living flood, from the metropolis which has been constructed with so much labour. Millions upon millions spread in all directions over the country, seeming to threaten universal ruin. But innumerable as are their swarms, enemies are ready to destroy them in every quarter, and within a day or two a few stragglers only of all these myriads are spared to recommence, in the ensuing spring, the foundation of their interesting colonies.

On reviewing the history of the Termites, we are naturally led to inquire why insects so voracious should be permitted to collect together in swarms which, according to our ordinary notions, are dangerous pests to the surrounding inhabitants. Man, always prone to make his own convenience the standard of utility, exclaims loudly against these marauders, as he is pleased to consider them, because his furniture and his property are sometimes sacrificed to their destructive propensities. The proceedings of Nature, however, are not to be judged of, or her operations trammelled by the petty notions of mankind. The labours assigned to the

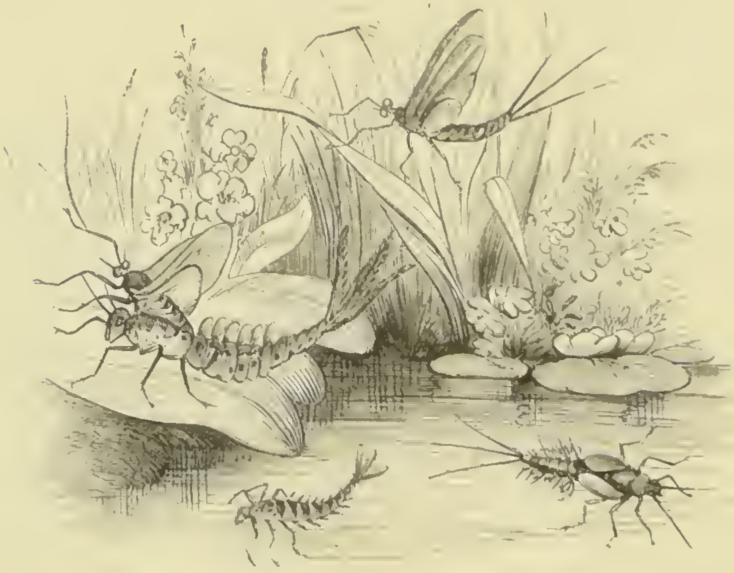
Termites in the economy of this world are of no trivial character; they, too, are important agents in Nature's grand police. Vast masses of decaying vegetation are annually removed by their agency; the fallen and useless timber which otherwise would encumber the forest, melts away before their hosts like ice in the sunshine, and work which could not be effected by other agency, is thus easily accomplished. True it is that they have not been taught to discrininate between the bough of a tree and a bed-post, neither are they sufficiently learned to distinguish between the leaves of the forest and the leaves of a book, but the march of Nature still goes on with unswerving steps, and the partial evil which they cause, interferes not at all with the universal good which they contribute, in their sphere, to promote.

Many Neuropterous insects are, in the early stages of their existence, inhabitants of the water, of which we have examples in the well-known Ephemera, or May-flies, which are not only remarkable on account of several important peculiarities in their economy, but are the prototypes of the fly-fisher's most successful lures, so that our brethren of the angle would scarcely pardon us for omitting the history of a race of insects which, to them, is possessed of such especial interest.

Few of our readers are unacquainted with the appearance of these elegant little creatures, still fewer have not admired their swarms as they dance merrily in countless thousands over the ponds and streams which are their usual haunts, alternately rising and falling, sparkling in the rays of the evening sun, like flakes of light, and apparently enjoying to the uttermost the brief span of life permitted to them in their winged condition.

Short indeed is the duration of their happiness. Their name (ἐφήμερος) would indicate that it is limited to a single day's existence, yet few of them enjoy so long a life. Of all the multitudes ushered into existence by the rays of the setting sun, not many are permitted to salute his rising beams, the majority of them perish within an hour or two after their appearance, and as they fall like flakes of snow into the water, afford abundant food to the hungry trouts that impatiently await the living shower.

Fig. 55.



Dr. Franklin's address, supposed to be delivered by "an ancient ephemera which had lived four hundred and twenty minutes," acquires, therefore, additional pathos from the venerable age which the insect had attained.

If, however, we trace the history of the ephemeron from the commencement of its existence, we shall find that it is as highly favoured with respect to longevity as the generality of other insects. During the first stages of its life it is an inhabitant of the water, in which element it passes two, or perhaps three, years, under a different form, certainly, but still in a state of active employment.

The May-fly on leaving the egg from which it is produced, finds itself an aquatic larva, the portrait of which is given in the annexed wood-cut (fig. 55). In this condition it has some slight resemblance to the perfect insect, but is totally destitute of wings; it has, however, six legs, which are strong and well-formed, so that it runs about with facility at the bottom of the water. In order to respire the element in which it resides, it is, moreover, furnished with a peculiar apparatus of breathing organs, situated on each side of the abdominal segments of its body, which seem to perform the office of gills, and consist of a series of membranous plates, arranged in pairs, which are kept in constant motion, and consequently may serve as fins wherewith to swim whenever the insect chooses to adopt this species of locomotion.

Thus furnished, the larvæ of the ephemera are fully adapted for a residence in water, where they may be met with at any time, lurking under stones, or concealed in the mud at the bottom. Some species, however, make for themselves burrows in the banks of the stream, in which they reside, and these abodes are constructed with much ingenuity. Instead of being straight holes bored into the bank, each burrow is bent upon itself, so as to have the shape of the letter U, and as it opens into the water at both extremities, the larva can pass in at one arm and out at the other without being subjected to the inconvenience of turning itself round in the narrow passage which it occupies.

While in the larva state, the ephemeron appears to subsist upon the *debris* of animal and vegetable substances, derived from the mud which it swallows, and with which its alimentary canal is always filled, affording another example of that economical appropriation of every particle of nutriment which can be made subservient to the support of life.

The pupa resembles the larva both in its form and habits, the principal difference being that it has the rudiments of wings developed upon the two hinder segments of the thorax, as represented in the figure (fig. 55).

When about to assume the winged state, the pupa crawls out of the water and proceeds to cast off its pupa covering, when it might appear to have completed its metamorphosis, for its wings seem fully developed, and it is able to fly heavily to the shore, where it alights upon the first support it can find. Here, however, it has yet another operation to go through, for it is found that after leaving the pupa-case, it is still covered with an exceedingly thin pellicle that must be cast off before it is fully free. To get rid of this last covering is, however, a work which generally occupies but a very few minutes, and the ephemeron at last released from all impediments, joins its fellows in the sunshine, until inexorable fate terminates its short career.

One sole business occupies this last brief portion of their lives: they find a mate, lay their eggs, and then immediately die. So limited, indeed, is the time allowed them, that were they to lay their eggs one by one, as other insects do, their lives would not be long enough for the performance of this last great duty; the ova are, therefore, expelled in a mass, and, falling into the water, are left to their fate.

The fly-fisher will at once recognise in the ephemera his old friends, which, under the names of "May-flies," "Drakes," and "Duns," are amongst his best flies, and here he will do well to observe that it is the female, when full of eggs, that is most eagerly taken by the fish; the males, sometimes called "bastards" by the fisherman, being far less attractive. The various kinds of "duns" represent the insect in that condition in which it is found before its last thin pellicle is thrown off, preparatory to the complete display of its wings, in which state its flight being as yet sluggish and feeble, it very frequently falls into the water, and is eagerly snapped up by the fishes, which, during the short period when the ephemera are abundant, gorge themselves with this their favourite food. The drake-season, so looked forward to by the "brothers of the angle," is at its height during the last week of April or the beginning of May, for then it is that the hosts of the ephemera make their appearance.

> "When with his lively ray the potent sun
> Has pierced the streams and roused the finny race,
> Then issuing cheerful to thy sport repair;
> Chief should the western breezes curling play,
> And light o'er ether bear the shadowy clouds.—
> Just in the dubious point where with the pool
> Is mixed the trembling stream, or where it boils
> Around the stone, or from the hollowed bank
> Reverted plays in undulating flow,
> There throw, nice judging, the delusive fly;
> And, as you lead it round in artful curve,
> With eye attentive mark the springing game.
> Straight as above the surface of the flood
> They wanton rise, or urged by hunger leap,
> Then fix, with gentle twitch, the barbed hook:
> Some lightly tossing to the grassy bank,
> And to the shelving shore slow-dragging some,
> With various hand proportioned to their force.
> If yet too young, and easily deceived,
> A worthless prey scarce bends your pliant rod,
> Him, piteous of his youth and the short space
> He has enjoyed the vital light of heaven,
> Soft disengage, and back into the stream
> The speckled captive throw. But should you lure
> From his dark haunt, beneath the tangled roots
> Of pendant trees, the monarch of the brook,
> Behoves you then to ply your finest art.
> Long time he, following cautious, scans the fly;
> And oft attempts to seize it, but as oft
> The dimpled water speaks his jealous fear.
> At last, while haply o'er the shaded sun
> Passes a cloud, he desperate takes the death,
> With sullen plunge. At once he darts along,
> Deep struck, and runs out all the lengthened line;

> Then seeks the farthest ooze, the sheltering weed,
> The caverned bank, his old secure abode,
> And flies aloft, and flounces round the pool,
> Indignant of the guile. With yielding hand,
> That feels him still, yet to his furious course
> Gives way, you, now retiring, following now
> Across the stream, exhaust his idle rage;
> Till floating broad upon his breathless side,
> And to his fate abandoned, to the shore
> You gaily drag your unresisting prize." *

The stone-flies (*Sialis*) likewise favourite baits of the angler, are also Neuropterous insects which abound during the spring months. Their eggs are to be found in immense numbers glued in thick ranks to the surface of rushes that overhang the water, into which the larvæ fall, and pass the first part of their existence. They very much resemble the larvæ of the ephemera, and like them breathe by means of false gills attached to the sides of the abdomen. When full grown these larvæ creep out of the water and burrow into the adjoining bank, forming cells wherein they become inactive pupæ, and thus await their last change, reappearing as sluggish, brown-winged insects, everywhere to be found upon stones and other objects near the water-side.

The remarkable history of the dragon-flies (*Libellulidæ*) must not be passed over in silence. These beautiful creatures, the largest and most active of our British insects, are pre-eminently distinguished by the rapidity of their flight, and the steadiness of their evolutions while "hawking" for prey in the vicinity of ponds and marshy grounds, where, in hot summer weather, they are everywhere to be met with. Equally conspicuous from their extreme activity, their gorgeous colours, and the exquisite structure of their wings, they might be regarded as the monarchs of the insect races. The very names selected for them by entomologists would testify the perfection of their attributes, their titles ranging from that of *Anax imperator*, indicative of imperial sway, to epithets expressive of feminine delicacy and lady-like grace, such as *virgo*, *puella*, *demoiselle*, and *damsel-fly*, which are appropriated to the sylph-like forms that many of them exhibit. In their habits, however, they by no means deserve the gentle appellations bestowed upon them ; they are, in truth, the tigers of the insect world, and their whole lives are devoted to bloodshed and rapine. Indomitable in their strength of wing, furnished with tremendous jaws, and possessed of acuteness of sight, and rapidity of motion scarcely to be paralleled, there seems to be no escape from their ferocity, and terrible is the slaughter they effect amongst the insect legions they are appointed to destroy.

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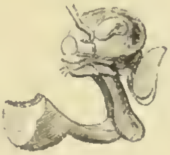
* Thomson.

Fig. 56.

But though in their winged state they are thus perfectly adapted to an aerial life, they, like the ephemera, pass by far the greater part of their existence in another element. The larva of the dragon-fly (fig. 56) is an inhabitant of the water, and may be met with in every pond, although, perhaps, the young naturalist would scarcely recognise it in its disguisement. In this condition it is extremely active, and being furnished with six agile legs, something like those of the perfect insect, it creeps about upon the stems of sub-aquatic plants in search of prey, which it seizes by means of a very curious apparatus provided for the purpose. This is constructed in the following manner: the lower lip of the larva is excessively prolonged, and folded upwards, so as to cover the face like a mask; it is moreover divided into two pieces, which, when not in use, fold down one upon the other, much in the same way as our arm bends at the elbow. At the extremity of the second piece, answering the purpose of a hand, are two triangular plates, deeply toothed, forming a pair of forceps, which can be opened and shut at pleasnre (fig. 57).

Fig. 57.



The manner of using this singular instrument may be thus described: the larva comes stealthily to within "striking distance" of its victim, when it suddenly lifts the mask from its face, opens the hinge in the middle so as to expand it to its full length, seizes the poor insect between the fang-armed plates at the end, and instantly folding up again this strange arm, carries the prey to its mouth to be devoured. The larva in the figure (fig. 56) is represented with this lower lip fully displayed in the act of catching hold of another insect.

Equally peculiar is the manner in which the larva of the dragon-fly respires. Its abdomen is terminated by a sort of tail, formed by five little horny pieces of a conical form, which the creature has the power of separating and closing again. On expanding these pieces, a valve, formed by three membranous plates, is opened, and a quantity of water enters the body, when the valves again close. The water thus taken in serves for respiration by being brought in contact with a peculiar apparatus communicating with the trachea, and is then forcibly discharged in a continuous stream to the distance of two or three inches by the action of a kind of piston. This singular contrivance, besides ministering to respiration, acts, moreover, as an instrument of locomotion, for by the violence of the stream forced out from its tail, the creature is propelled through the water much in the same manner as a sky-rocket shoots into the air, and thus its progress in its native element is materially assisted.

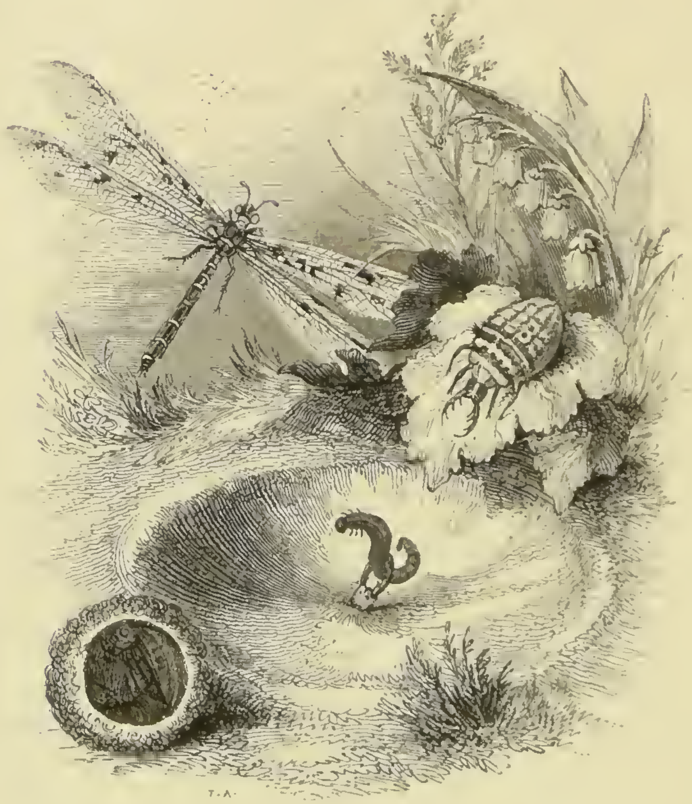
After several moults the rudiments of wings are discoverable upon the thoracic segments enclosed in the skin of the pupa-case, but with the exception of the presence of these organs, the pupa (fig. 56) very nearly resembles the larva. Ten or twelve months are thus spent in the preparatory states by these insects, when at length the pupa creeps up the stem of some plant, and emerges from the water; it then casts its pupa-skin, and revealing the lineaments of the dragon-fly, enters upon its new state of existence.

The ant-lions (*Myrmeleonidæ*) form another interesting group of Neuropterous insects, and, although not indigenous to this country, merit attention from the singularity of their habits. In their perfect state the ant-lion very closely resembles a dragon-fly, and, like it, is eminently predaceous, its excursions being principally confined to the evening, for during the day-time it conceals itself amongst the leaves of trees and plants, in which situation it is so securely hidden, that its capture is not easy to accomplish.

It is in its larva condition, however, that it principally requires our attention. In this state it has not the slightest resemblance to the adult animal, its whole construction being made subservient to its singular mode of life. In the succeeding figure (fig. 58) one of these larvæ is represented placed upon a leaf. Its body forms a large oval mass, something like that of a spider, to which the head is attached by the interposition of a very moveable neck; its jaws are considerably longer than the head, and in their shape might be compared to a strong pair of callipers, toothed along the inner margin of each blade, so that they constitute a very efficient pair of forceps.

The larva ant-lion will only feed upon such game as he catches himself; nevertheless he is perfectly unable to hunt even the slowest paced insects, for not only are his movements excessively tardy, but when he does walk, from the position of his legs, and the uses to which they are adapted, he is only able to move backwards; nevertheless, he manages

Fig. 58.



to feed luxuriously, by employing a stratagem, the effect of which is that the game positively falls into his jaws, which he has nothing to do but to open and receive. Selecting a sandy soil, and choosing a situation beneath the shelter of some wall or tree, so as to be protected as much as possible from rain, the ant-lion proceeds to excavate a conical pit, which he accomplishes by throwing out the sand with his long jaws, as he continually walks backwards round and round until a deep conical excavation is formed in the loose sand, at the bottom or apex of which the creature buries himself, and there remains quietly concealed, with the exception of his jaws, which are kept half open and ready for action. Thus ensconced, woe betide any imprudent insect that unhappily passes too near the margin of his pitfall: no sooner does it approach the fatal brink than the loose sides, giving way beneath its feet, the unfortunate traveller is precipitated to the bottom of the ant-lion's den, and falls at once into the jaws of its destroyer. Its fall, however, is not always so headlong as to preclude all attempts to escape; the insect, sometimes perceiving the danger, tries to lay hold upon the grains of sand at the border of the dreadful gulf; some yield beneath its feet, and it sinks lower and lower still; at last, with desperate efforts, it succeeds in getting hold of some piece of earth more stable than the rest, whereby it holds, or even attempts to regain the top of the dangerous steep; but the bandit has still a resource to enable him to secure his escaping prey; with the top of his flattened head, which he uses as a shovel, he throws up a deluge of sand that, falling in showers upon the miserable victim, already exhausted with its futile efforts, soon brings it to the bottom, there to become an easy prey to the ruthless savage. On the other hand, being entirely dependent for food on such a precarious supply, the ant-lion must not only necessarily exercise great patience, but be able to put up with very prolonged fasts, and accordingly, as has been proved by experiment, he can occasionally pass months without eating, and still remain in apparent health; indeed, M. Poupart was almost led to believe that they only ate for amusement, seeing that some which he kept, after fasting for a great length of time, underwent their metamorphoses as usual; but, doubtless, these had nearly left off eating of their own accord, preparatory to their change at the time when he imprisoned them.

When about to assume the pupa-condition, the ant-lion digs deeper down into the sand at the bottom of its pit-fall, and there, by means of a silken thread spun through a tubular spinnaret situated near its tail, it envelopes itself in a spherical cocoon, almost resembling that of a silk-worm, wherein to pass its helpless and quiescent state. In effecting this, however, it has a serious difficulty to encounter: to spin a silken cocoon in the open air might seem a sufficiently difficult task, but in the case before us the cocoon has to be manufactured while the insect is closely packed in loose dry sand, the particles of which must, of course, press it closely on all sides, and yet, in order to construct its pupa-case, it must necessarily have room to turn round and round freely as the work advances. The mode of its procedure is as follows. It first spins a silken web above its body, with which the sand is matted together into a sort of hemispherical roof, which keeps the loose earth from falling upon it, and then, beneath the shelter of this tent, excavating by little and little. As its work proceeds downwards, it manages to form a subterranean cavern, in which to await its final change. On emerging from its retreat, it presents itself under the aspect represented in the figure—an insect not unlike the dragon-fly, both in appearance as well as in its tyrannical habits, and, although possessed of feebler powers of flight, scarcely less destructive to the insect races.

The beautiful lace-winged flies (*Chrysopa*) common in our own country, are not very dissimilar from the ant-lions, although they dig no pitfalls. These insects, with their bright green bodies, golden eyes, and iridescent wings, are, in their perfect state, lovely objects. The female lays her eggs upon the leaves of plants, to which they are attached in a very curious manner. The insect first fixes to the leaf a small quantity of a tenacious gum-like fluid, which is sufficiently viscid to be drawn out into a long filament, upon the furthest end of which the egg is attached; so that, when the filaments are hardened by exposure to the air, each egg is suspended at the extremity of a slender foot-stalk.

The larvæ hatched from these eggs, have been named by Reaumur Aphis-lions; for, no sooner do they get on to the plants than they attack the aphides, or plant-lice, with insatiable fury, and are thus, doubtless, of incalculable benefit to the gardener. Some of them cover their bodies with the skins of their victims, so as to render themselves almost invisible amongst the heaps of exuviæ around them. When full fed they spin silken cocoons, by means of a spinnaret situated at the extremity of their body, and, enclosed in this, await their final change.

CHAPTER XI.

PHRYGANEÆ, OR CADDIS FLIES.

"WHEN I would beget content," says honest Isaac Walton, "and increase confidence in the power, and wisdom, and providence of God, I will walk the meadows by some gliding stream, and there contemplate the lilies that take no care, and those very many other various little living creatures that are not only created, but fed, man knows not how, by the goodness of the God of Nature, and therefore trust in Him."

To the fisherman, who takes up his rod in this spirit, the history of his favourite flies cannot fail to possess considerable interest, more especially as their habits, in every stage of their existence, offer proofs of the providential care above alluded to, well deserving the attention of every student of Nature.

The insects belonging to the order TRICHOPTERA, called by entomologists, *Phryganeæ,* are well known to the angler, in every stage of their growth, as excellent baits for fish. In their perfect condition they are distinguished from all other races by the peculiar structure of their wings, the front pair being covered with a hairy clothing,[*] with large branching nervures, while the hinder pair are broader, and folded when at rest. In their larva condition they are aquatic grubs, inhabiting factitious tubes, constructed of various materials, under which aspect they are called "caddis worms," "cad-bait," "stick-baits," &c. These grubs (fig. 59) are furnished with six jointed legs attached to the three anterior segments of their body, with the aid of which they crawl slowly about at the bottom of the water. The hinder segments are without any legs, but, in some species, are provided on each side with delicate fringes, which, performing the office of gills, are the instruments of respiration. In other species, however, these external branchial organs, are wanting; in which case the larva breathes by means of spiracles, situated along the sides of its body. The head is horny, and furnished with a pair of strong jaws, armed with several small teeth, adapted to devour vegetable substances; but they are by no means restricted to this kind of diet, as they will attack the larvæ of aquatic insects, and even those of their own species. Still the greater number are said to be purely herbivorous, eating the leaves of the willow-tree, and others which accidentally fall into the water.

The hinder portion of the body of the caddis-worm being extremely soft, it has been instructed by Nature to clothe itself in a suit of armour of unique construction. To the under-lip of the grub is attached a spinnaret, similar in every respect to that with which so many caterpillars are furnished; from this it can produce a silken thread; and thus provided with no other tools than its feeble legs, it sets about the formation of its ingeniously-constructed residence, employing such materials as are adapted to the particular necessities of the species to which it belongs. Several kinds of these curious portable houses are figured in an interesting little volume, published in the Library of Entertaining Knowledge, together with some good observations relative to the manner of the fabrication,* of which the substance is as follows.

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[*] Whence the name of the order from *ϑριξ*, *τριχος*, hair, and *πτερον*, a wing.

Among the materials used by these singular grubs may be mentioned, sand, stones, shells, wood, and leaves, which are skilfully joined together, and strongly cemented. When leaves are employed, they are glued together longitudinally, (fig. 59*h*) with their ends pointed backwards, so as to form an imbricated cylinder, the leaves in front overlapping those behind, like the tiles of a house. Another species employs pieces of reeds or of grass, straw, wood (59 *e f*), &c., cut into convenient lengths, carefully joining and cementing each piece to its fellows as the work proceeds; and, moreover, the tenement is not unfrequently finished by adding a broad piece, longer than the rest, to shade the door-way over head of the occupant, so that he may not be seen from above. A still more laborious fabric is constructed by others, which weave together the leaves of aquatic plants into a roundish ball, and, in the interior of this, form a cell for their abode. A fourth kind of these ingenious architects makes choice of the tiny shells of fresh-water mollusca, with which it constructs a moveable grotto (fig. 59 *g*); and as these little shells are for the most part inhabited, the poor animals contained in them are unceremoniously dragged about at the mercy of the tyrant whose prisoners they have become. These grotto-building grubs are by no means uncommon in ponds; and in chalk districts, such as the country about Woolwich and Gravesend, they are very abundant.

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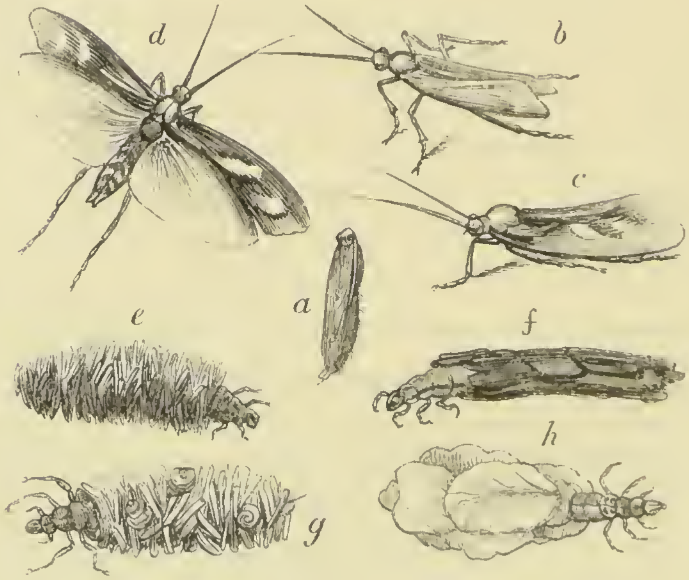
* Insect Architecture, p. 185.

One of the most surprising instances of their skill occurs in those structures, in the building of which small stones are employed as the principal material. The problem is, to make a tube, about the width of the hollow of a wheat-straw or a crow-quill, the cavity of which shall be throughout smooth and uniform. Now the materials being small stones full of angles and irregularities, the difficulty of accomplishing this will appear to be considerable, if not insurmountable; yet the little architects, by patiently examining the stones, and turning them round on every side, never fail to succeed in their undertaking. This, however, is only part of the task, which is complicated with another condition, namely, that the under surface shall be flat and smooth, without any projecting angles, which might impede its progress when dragged along the bottom of the rivulet which these stone-builders generally frequent. The selection of the stones as materials for building, may indeed be accounted for from the circumstance that this species inhabits running streams, where, but for the weight of its house, it would to a certainty be swept away by the current. In order to guard against such an accident, it is

Fig. 59.



probable that the caddis makes use of larger stones than it would otherwise want; and doubtless from the same reason, cases are frequently met with which, being composed of very small stones and sand, have a large stone added to them when nearly finished, by way of ballast. Or the reverse of this is sometimes seen, when the materials employed, having been found to possess too great specific gravity, a bit of light wood or a straw is added, to render the edifice more buoyant.

We have repeatedly, says Mr. Rennie, the writer of the above remarks, tried experiments with the inhabitants of these aquatic tents, to ascertain their mode of building, by depriving them of their houses, and furnishing them with materials for constructing new ones, so as to be enabled to watch their proceedings, from their laying the first stone or shell of their structure. They work at the commencement in a very clumsy manner, attaching a great number of chips to whatever materials may be within their reach, by means of loose threads of silk : and many of these they never use at all in the construction of their residence. They act, indeed, much like an unskilful workman trying his hand before committing himself upon an intended work of difficult execution. Their main intention is, however, to have abundance of materials within reach ; for after their dwelling is fairly begun, they do not again protrude more than half of their body in quest of substances wherewith to build; and even when they have dragged a stone, a shell, or a chip of reed within building reach, they have often to reject it as unfit for their purpose.

Some species, instead of constructing moveable houses, fasten their cases firmly to the surface of large stones, and consequently have to quit their retreats whenever they go in search of food. These, however, have their bodies covered with a firmer integument than the residents in locomotive habitations, and consequently are better adapted to such a kind of life.

In the construction of their cases, whether the materials employed be simply bound together with silken filaments, or, as some writers assert, also united by means of a peculiar cement, the connecting substance, which is necessarily at first produced in a fluid state, must have the property of hardening under water,—a circumstance by no means to be overlooked by those who would appreciate the difficulties that have to be surmounted in the formation of these remarkable defences.

When about to change from the larva to the pupa condition, those species which inhabit moveable cases, fasten them securely by silken cables to some fixed object, and then proceed to fortify their domiciles, so as to guard against aggression from without during their torpid or quiescent state. This they accomplish by weaving a screen or grating of strong threads, composed of thin insoluble silk, which they have the power of manufacturing into network, constructed after various patterns, whereby a free admission and exit of water is secured to the pupa, for the purpose of respiration; and all intruders are at the same time effectually kept out. One of these curious grates, described by De Geer, resembles a plate of perforated zinc, being composed of a circular lamina of brown silk, as hard as gum, stretched across each aperture of the case, a little within its margin, and perforated all over with holes, arranged in concentric circles and separated by ridges, which run from the centre to the circumference, like the spokes of a wheel. These radii are crossed by other circular ridges, which follow the direction of the circles of holes, so that the two sets crossing each other form compartments in the centre of each of which is an aperture (fig. 59).

Thus secured, the creature proceeds to cast off its larva skin, and presents itself as an inactive pupa, having much the appearance of the perfect insect, —the antennæ, palpi, wings, and legs being all conspicuous, but shorter than those of the imago, and enclosed in separate cases, wherein they are beautifully folded up. The phryganeæ are likewise, in the pupa state, furnished with a pair of strong horny and hook-like jaws,—a circumstance sufficiently worthy of remark, when the reader is informed that the perfect insect, which never eats, is without such organs, and the inactive pupa of necessity takes no food. These jaws are indeed required for a very special purpose, and their adaptation to the object in view cannot but excite admiration; for when the period arrives for their imprisonment to cease, it is manifest that, without some tools adapted to the work, the nascent insects could never burst the prison-bars of their own construction, and their escape would consequently be impossible.

To obviate this difficulty, just prior to its final change, the pupa-phryganea begins to show considerable activity; and the first use that it makes of its newly-formed powers is, by means of its jaws, now used for the first and last time, to tear away the silken grating of its cell, and thus make a way out of the case it is about to abandon for ever.

Having succeeded in getting free, the now active pupa crawls about at the bottom of the water, and even swims with facility; but in this condition it remains but for a very short period, preparatory to its entrance upon the last and winged state. The time for undergoing this change having arrived, the pupa proceeds to leave its native element. For this purpose it climbs the stem of some reed or tall blade of grass, by the assistance of which it gets above the surface of the pond, and in this position throws off the coverings concealing its perfect limbs, and, spreading out its wings to dry, soon becomes able to join its companions in the air, and flutter about, while it fulfils the last duties of its life.

After laying its eggs, it speedily perishes, and finds a ready tomb in the capacious maw of some hungry fish, which is eagerly looking out for such welcome prey.

CHAPTER XII.

HYMENOPTEROUS INSECTS.—ANTS, WASPS, HORNETS, ETC.—HISTORY OF THE HIVE-BEE.

Among all the insect races, none are so remarkable for the perfection of their instincts, and the Herculean labours they achieve, as the Hymenoptera. In whatever point of view we consider the different members of this extensive group, whether as examples of patient industry and untiring perseverance, or as possessed of knowledge and forethought apparently superhuman, they stand conspicuously pre-eminent.

The first group of hymenopterous insects which courts our notice, comprises the ants (*Formicidæ*), the interesting details of whose history might, in itself, fill volumes. Unlike the families described in preceding chapters, the ants congregate together in large societies, all the members of which industriously labour for the general community; but as such numerous swarms, if their powers of reproduction were not jealously circumscribed, would speedily become dangerous, Nature has here, as in the case of the Termites, described in a preceding chapter, made special arrangements to guard against their undue multiplication, by rendering the great majority of the members of the colony sterile—a provision which, indeed, answers a double purpose, by leaving them at leisure to devote their undivided attention to the labours of the commonwealth.

A colony of ants consists, therefore, of two distinct classes — the *neuters*, or *working ants*, upon whom devolve the duties of constructing their place of abode, collecting provisions, and taking care of the young, in all of which their exertions are untiring and their perseverance exemplary; and of the fertile ants, divisible, of course, into males and females, which alone are permitted to propagate their race. During the greater part of the year, indeed, the community consists of neuters alone, the males and females being only produced towards the latter end of summer, so that they have but little share in those operations for which the working ants are so celebrated.

The neuters, too, as it appears from recent observations, may be divided into two classes, namely—ordinary workers and soldier-ants; the latter being distinguishable by their larger size, and likewise by the great development of their heads and robust jaws, in which particulars they resemble, to a certain extent, the military police of the Termites.

One of the most important duties assigned to the working ants, is the construction of their common residence; and, as each species adopts a peculiar plan, there is considerable difference in the arrangement of these "formicaries," as they are termed by naturalists. Some species (*Formica fusca*, &c.) are subterranean in their habits, and excavate for themselves very extensive premises, tunnelling the ground in all directions with the skill of railway engineers, and thus forming passages of intercommunication between the numerous store-houses, nurseries, and other departments belonging to the establishment. Some build above the surface of the ground, in addition to the excavations which they form beneath, employing for this purpose various kinds of building materials, some preferring bits of sticks, straws, leaves, and other similar matters, which they pile up into a conical mass, usually denominated the ant-hill — whilst others build similar mounds with earth or clay, which, although rude enough in their external appearance, exhibit within an admirable arrangement. The colonies of the black ant (*F. fuliginosa*) live in the trunks of old trees, which they excavate in all directions, forming many stories of galleries and warehouses. Others use sawdust in forming their buildings, which they work up into a kind of *papier-maché*. Mr. Westwood enumerates various other forms of these nests described by different authors: thus, the *F. flava*, an inhabitant of Cayenne, constructs its nests of the cottony matter, enclosed in the capsules of bombax, forming it into a spongy mass, that is used as *amadon*, or as a means of stopping the most violent hemorrhages. Certain green ants, in New South Wales, mentioned in "Cook's Voyages," construct their habitations, which are sometimes as large as a man's head, in trees, by bending down the leaves and gluing their tips together. The above examples must, however, answer our present purpose, and we may now proceed to notice a few of the most remarkable traits in the history of our indigenous species.

The neuters, or working ants, seem to be perfectly aware that, in order to accomplish the Herculean labours imposed upon them by the necessities of the general community, it is essential that the numerical strength of the colony should be supported by every available means, and so strongly do they seem to be impressed with this circumstance, that every possible effort is made to maintain or even to increase their working population.

One of the most striking features in the economy of the ants is, the unceasing care that they take of the young larvæ and pupæ, which seem to be the common property of the colony. Was this affectionate zeal for the welfare of the progeny of the ant-hill confined to the parent insects, there would indeed be little remarkable in the circumstance; but when we remember that all this anxious solicitude is manifested by the working ants, or neuters, who cannot be supposed to be actuated by parental instinct, such a strange transfer of affection is not a little wonderful.

The females, who are the original foundresses of the community, lay their eggs at three different periods, those which are to give birth to neuters being first produced in very great numbers, whilst those from which males and females are to be hatched, are only laid towards the end of the season. The eggs, when first deposited are very minute, but, as is the case in many other races of insects, they increase in size considerably before the escape of the larvæ, which are small white grubs, entirely destitute of feet, and totally dependent for their supply of food upon the assiduous bounty of the working ants, who constantly feed them by pouring into their mouths a nutritious fluid, which they have previously elaborated in their own stomachs, and subsequently disgorged.

When the larvæ have attained their full growth, those species which are destitute of a sting enclose themselves in little oval cocoons, which they manufacture of very delicate silken threads, so closely woven that they resemble fine parchment, and in these cocoons they change into pupæ, which, as in the case of other hymenopterous insects, have all their limbs developed and neatly folded up upon their breast. Those species which are provided with a sting, are said not to spin any cocoon, so that their pupæ are left unenclosed by any covering.

When the period arrives for the escape of the imago, the attendant working ants gnaw a hole at one end of the cocoon, to allow the imprisoned insect to escape, which, being accomplished, it casts off the thin pellicles in which its limbs were ensheathed, and soon presents itself, a full-grown ant, provided with wings if it be a male or female, but if a neuter, destitute of these appendages.

Whether in the egg, the larva, or the pupa condition, however, the young ants are indefatigably taken care of by the busy workers, whose charge is to attend upon them. In fine weather they are regularly brought up to enjoy the influences of sun and air, and again removed into the interior of the works on the approach of cold or wet. Neither is this by any means the extent of their devotedness. Should danger threaten, the young brood is their first care, and all fear for their own personal safety seems to be swallowed up in their anxiety to preserve the precious charge consigned to their keeping. Frequently, in mountain districts where the ants construct their formicaries beneath the shelter of some large stone, we have suddenly lifted up the roof of their citadel, and exposed to broad daylight the busy crowd of labourers beneath, together with the eggs and cocoons under their charge. Terrible, doubtless, to their apprehensions must be the calamity which thus invades their colony, comparable only to the earthquake at Lisbon, or the destruction of Pompeii, or similar instances of overwhelming desolation which have at times befallen cities raised by man; and yet, amidst all the alarm and tumult of the moment, the predominant anxiety seems to be for the preservation of the eggs and cocoons that are lying exposed to danger; these are instantly seized upon, and carried down into the penetralia of the citadel, nor do the ants relax their efforts until, braving every danger, they have succeeded in rescuing the helpless progeny of the nest.

Wishing to see to what lengths of daring they would go in risking themselves in defence of their precious charge, we have frequently taken the young ants and thrown them upon the webs of spiders, that generally abound in the vicinity, but even there they were speedily discovered, and, although apparently fully aware of the danger of the undertaking, volunteers would soon present themselves, ready for this "cutting out service," who, dashing fearlessly on to the web of their wily enemy, would not cease their efforts till every individual was saved.

A similar instinct urging them to provide for the numerical strength of the community, no doubt prompts their conduct towards those female ants that are first hatched from their cocoons. These being winged, would at once fly away to found colonies elsewhere, did not the neuters effectually prevent such desertion by seizing the prolific individuals, and unceremoniously biting off their wings, so that, *nolens volens*, they are compelled to contribute to increase the population of their native ant-hill.

To the same necessity, doubtless, must be referred the extraordinary proceedings of certain species of ants which make slaves of others, and employ them, perforce, in working in a foreign nest, for the benefit of strangers. Assembling in large armies, these slave-making ants issue forth in martial array and, after tedious marches, conducted with perfect order and regularity, arrive in the territories they are about to invade; bloody battles are fought between these myrmidons, whose prowess seems to be in every way worthy of the Homeric muse, and it is only after vast slaughter on both sides that they succeed in getting possession of the strongholds of their opponents, which are at once devoted to sack and pillage. The booty sought for, however, consists of the eggs, larvæ, and cocoons of the vanquished, which are seized upon with the utmost eagerness, and carried in triumph back to the city of the victors, where, it would appear, their treatment is by no means barbarous, for, being hatched in the domains of their conquerors, the enslaved race seem to work as happily as if they were heirs to the soil, and laboriously toil for their more warlike but less industrious masters.

It is not true, as is generally supposed, that the ants, at least those of our country, lay up a store of provisions to last them during the winter months: on the contrary, the workers all perish at the approach of winter. But the males and females, having acquired their wings, selecting a favourable day, issue in vast swarms from the formicary where they have been so carefully nursed, and, flying into the air, sport a while upon the wing. The males speedily perish, as likewise do the majority of the females; a few of the latter, however, escaping the general destruction, succeed in finding a situation where to found a new colony, when, voluntarily tearing off their own wings, they commence their arduous task, and lay the foundations of a kingdom which, in the ensuing season, will exhibit the same scene of activity and industry as that of the preceding year.

The last section of the predacious Hymenoptera comprises the different families of wasps, so much feared for the potency of their stings, but unfortunately too little appreciated as active and useful agents in the economy of Nature, possessed of instincts well calculated to excite the admiration of any one who pays but ordinary attention to their habits.

The insects known by the general term of wasps, may be divided into two groups, viz., those which live solitarily, and those which associate together in large societies, each of which will deserve our attention.

The solitary wasps, of which there are several genera, live in pairs (male and female), and are frequently called mason-wasps, from the peculiar manner in which they construct their nests of particles of sand, bits of earth, and similar materials, thus forming cells in which they rear their young. In the formation of these nests, various plans are adopted by different species, of which it will be advisable to give a few examples.

Some (*Odynerus muraria*) excavate burrows in sandy soils, which might be compared to the burrows in a rabbit warren, were it not that they are of much more artificial construction. An ordinary burrow, left open at the mouth, would be constantly exposed to the intrusion of various visitors,—some not of the most friendly character ; and in order to avoid such annoyance, these wasps defend the entrance to the retreat in which they are about to lodge their young, by a very ingenious contrivance. Making use of the grains of sand procured from its excavation, which it cements together for the purpose, the parent wasp builds a tube something like a little chimney-pot, but of a curved form, around the mouth of her burrow, the entrance to which is thus to a certain extent protected, while she is at work. At the bottom of this burrow she constructs the cells in which she lays her eggs, enclosing with every egg a number of green caterpillars, which are to serve as food for her progeny, as soon as it is hatched and capable of eating. Having thus provided for the wants of her future offspring, the parent insect carefully closes the orifice of the tube, at the entrance of the burrow, and leaves her young in safety. The larvæ thus abundantly provided for, live upon the caterpillars, and at last leave the burrow, perfect and full-winged wasps.

Another species (*Eumenes coarctata*) builds its nests upon the stems of plants, especially heath. These nests are constructed of very fine earth, and are of a spherical shape. Instead of caterpillars, however, the cell is in this case filled with honey, upon which the larva feeds until it undergoes its metamorphosis.

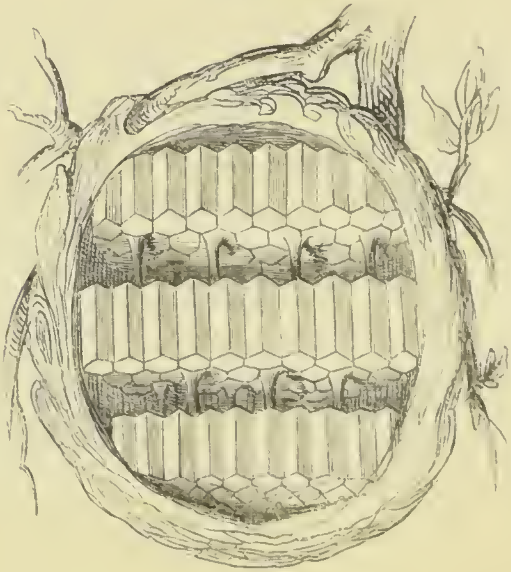
Other species are not at all particular as to the locality in which they build, but will use a cavity between the bricks of an old wall, a hole in a tree, the hollow stem of a stick after the pith has been scooped out, a key-hole, or any other hollow that seems adapted to their purpose.

VESPIDÆ (Wasps).—The social wasps, like the hive-bees, live in societies, and in many respects equal or even surpass the more useful inhabitants of the hive, in the industry with which they carry on the labours necessary for the welfare of their progeny.

The occupants of the wasps' nest are divisible into three different classes, namely, the *males*, the *fertile females*, and the *neuters*, which latter constitute by far the most numerous portion of the colony, and correspond to the working bees; but the distinctive name of *workers* would, in their case, be by no means so appropriate as in that of the honey-making bees, seeing that the queens themselves are the most industrious labourers for the general good; and if the males are inferior in industry to the neuter wasps, they are by no means idle spectators of what is going on around them, but willingly co-operate with the rest to the extent of their ability. We must, however, trace the history of the colony from its commencement, and thus simplify as much as possible our survey of what takes place in the busy interior of the vespiary.

No sooner does the genial warmth of returning summer recal the insect world to bustle and activity, than the few females which have escaped the inclemencies of winter (and, fortunately for us, these bear a very minute proportion to the multitudes which have perished), may be seen solitarily but most assiduously flying backwards and forwards in search of a proper spot where to build, each anxiously solicitous to secure a commodious and safe locality for the colony of which she is to be the sole and unassisted foundress. This, in truth, she is, in every sense of the word, exhibiting an example of patient and untiring industry, perhaps without parallel; and we certainly must feel disposed, when we have learned the history of her exploits, to agree with Reaumur, in exclaiming, that if there be such a thing as glory known among insects, and if, as with us, substantial glory is achieved by surmounting all difficulties in the attainment of an object conducive to the common weal, every mother-wasp is indeed a heroine. All the host of labourers associated with her at the close of the preceding autumn, have perished; yet, alone and unassisted, she commences a colony, soon to become more populous than that of the Carthaginian Dido. Nevertheless, as the pendulum in the fable, when disheartend with the prospect of having to perform so many vibrations during the coming week, took courage from the re-

Fig. 60.



flection that a week would be allowed to perform them in, so does the foundress of the wasp-nest enter with alacrity upon her Herculean task, satisfied that her labours will at last be crowned with success.

Her first operation is to dig to a very considerable depth underground, and then to excavate a cavity in the earth, large enough to contain her first-formed citadel,—a labour that, in itself, might appear incredible, especially when we consider that her little jaws must perform the duties both of spade and wheel-barrow, these being the only tools permitted her to work with.

At last, by patient industry, this first great task is got through, a passage and a chamber are completed of sufficient size to suit her purpose, and she then prepares to enter on new toils, demanding even greater and more prolonged perseverance, namely, the construction of the cells in which her eggs are to be laid. These cells are of the same general shape as those of the hive-bee, but are constructed of a very different material: for the accommodation of the queen-bee, thousands of workers are employed to build nurseries for her progeny, but the poor mother-wasp not only has to build the houses for her young herself, but must collect, at a distance, all the materials employed in their construction, and transport them with great labour to the locality where she is about to found the infant colony. Her cells are not formed of wax, but are built of woody fibres, scraped by her strong jaws from the outsides of weather-beaten posts or rotten timber; these fibres she brings by mouthfuls at a time, home to her domicile, and, having chewed this material to a kind of paste or *papier-maché*, adds it bit by bit to the slowly rising walls of her solitarily built citadel. Let the reader therefore judge, how many toilsome journeys must be taken, how many loads brought home and skilfully adjusted, before this huge task is accomplished, and a sufficient number of cells prepared to receive the eggs she is about to lay.

Having achieved thus much, she next proceeds to lay her eggs, placing them individually in cells adapted to the necessities of the progeny; for, as among the bees, each variety of egg requires a cell of appropriate dimensions.

Each egg is deposited singly in its cell, and glued to the bottom of it, by one extremity, so firmly that it is difficult to detach it without breaking the shell. In six or seven days, the eggs are hatched, giving birth to small grubs, almost exactly resembling those of the bee, and equally helpless, requiring constant attention during their growth, so that the mother-wasp has to devote her undivided attention to them, feeding them as birds feed their nestlings by putting food into their hungry mouths. Her activity, indeed, is astonishing, as she runs incessantly from cell to cell, supplying their wants with ceaseless diligence. The wasp-grubs, as soon as they have grown to such a size as to fill the cell, are ready to undergo their metamorphosis, during the accomplishment of which period they have no need of food. Before assuming the pupa state, the wasp-grubs close up their own cells with a strong membrane, resembling white silk, composed of an extremely fine thread, that is produced in the same manner as in other silk-spinning larvæ. The grub then soon becomes transformed into a pupa, and on about the eighth or ninth day eats its way through the covering of its cell, and emerges a perfect wasp, ready at once to enter upon its duties. The cell, however, does not remain long vacant; the mother-wasp immediately proceeds to cleanse it, and render it fit to receive another egg, which she deposits in it forthwith.

But now a very different scene begins to develope itself in the interior of the wasp's nest; as, in rapid succession, the young wasps, the progeny of their hitherto solitary parent, emerge from their cells, and all becoming at once active, the business of the colony proceeds apace. New cells are built in numbers proportionate to the increased supply of labourers, and every female wasp that escapes from the cells, being fertile, the number of eggs that they lay is very great, and, by the end of autumn, not fewer than sixteen thousand cells are sometimes found in a vespiary, each of which has, during the season, contained three successive occupants; so that, at a moderate computation, the mother-wasp may see at the close of the year, a family of thirty or forty thousand descendants.

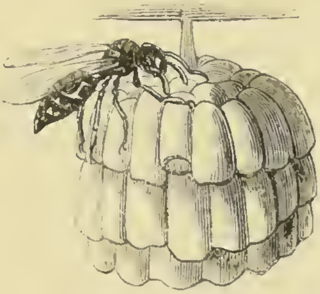
Such is the scene of business and activity which is enacted in the interior of a wasps' nest during the summer and autumnal months; but no sooner does the approach of winter announce itself, than Nature proceeds to destroy and to undo all that has been accomplished with so much care and incessant labour.

About the commencement of October, the conduct of the hitherto affectionate and industrious inhabitants of the colony undergoes a strange and cruel change. The wasps suddenly cease to employ themselves with nourishing their young brood, and from being such tender mothers or nurses, they become converted into pitiless murderers, and, tearing from their cells all the as yet imperfect larvæ, they destroy them with their jaws, and drag their mangled carcases out of the precincts of the vespiary. None are spared in this general massacre; all are butchered, and that in obedience to circumstances which it is not difficult to understand. The reason of this wholesale slaughter is, that the wasps foresee the scarcity of food that must soon ensue, and seem to know that their offspring would inevitably die a lingering death by famine, or perish from the cold, were their existence not thus summarily terminated.

As soon as the first frost is felt, the wasps themselves never come out of their retirement, except during the hours of sunshine, and then only to cluster sluggishly together in the immediate vicinity of their nest. When the cold gets a little more severe, they seem to lose all their strength, not having vigour enough left to enable them to chase away the flies, that appear to insult them by crawling into their citadel, and in a little time they all perish, with the exception of a few robust females, which, having survived the winter without eating, are ready, at the commencement of the next season, to found new colonies and recommence the scene we have been describing.

Other species of social wasps, instead of excavating their nests in the ground, construct them upon the branches of trees. These tree-nests, which are all composed of a papyraceous substance, are manufactured from the fibres of wood, or some similar material, cemented together. They are of a globular form, and consist, externally, of several layers, superimposed one over the other, the cells being regularly disposed in the cavity formed by this external envelope. We have seen a nest of this description, built upon a rose-tree in a gentleman's garden, near a paper-manufactory, in the construction of which the fibres of paper had been exclusively made use of, and, oddly enough, the tasteful architects of this pretty fabric had employed white paper, and then blue paper alternately, so that the nest had exactly the appearance of a blue-and-white damask rose.

Fig. 61.



Mr. Westwood mentions a species (*Chartergus nidulans*), a native of Demerara, which suspends its nest, by a ring, from the topmost branches of trees, so as to swing backwards and forwards with the wind, and to be out of the reach of monkeys. This nest is in the shape of a truncated cone, and is composed of a very fine substance exactly like card-board. The combs, which increase in number with the increasing population (the nest sometimes attaining a very large size), are circular, but convex on the under side, with a central aperture for the ingress and egress of the inhabitants; they are attached to the general envelope through their entire circumference; the bottom layer, so long as it serves as the bottom of the nest, is smooth, but when a fresh layer of cells is required, these are built upon the under side of this bottom, with their open ends directed downwards, and a fresh bottom is then added, the central orifice serving to allow a passage through all the rows of cells.

Various other modifications in the construction of these vespiaries might be pointed out; but the above examples will serve our purpose, and give the reader a general idea of the wonderful instincts bestowed upon the social wasps.

The last division of hymenopterous insects embraces the whole tribe of bees, which are at once distinguished by the faculty they possess of making honey, with which and the pollen collected from flowers, they feed their young during their larva state. To enable them to collect the pollen, they are generally furnished with certain organs, of a very peculiar structure, called the "pollen-baskets," and the "pollen-brushes." The pollen-basket is a naked portion of the body of the bee, which is either slightly hollowed or quite flat, surrounded with a fringe of hairs, so as to enable it to retain the grains of pollen. In the working hive-bee, and in the humble bee, these pollen baskets are situated upon the outer side of the hind leg; but in other genera, they are placed upon each side of the metathorax, and the corresponding surface of the posterior thighs.

The "pollen-brushes" consist of bundles of hairs, attached to the hinder legs or to the under side of the abdomen, wherewith the pollen is swept together, in order to facilitate its collection.

The honey itself is elaborated in the stomach of the bee, from which it is regurgitated into the cells of the honey-comb, wherein it is stored or used immediately as food.

The first family of the *Mellifera*, or honey-making bees, consists of genera which very closely resemble in their habits, the solitary wasps described in a preceding page. The members of this family (*Andrenidæ*) live together in pairs (male and female), and construct burrows in the ground, in which to make the cells for containing their eggs, depositing in each cell an egg and a supply of pollen-paste, which serves for the food of the future larvæ. After this, the burrows are carefully closed up, and the young bees left to make their escape by their own exertions, after the completion of their metamorphosis.

Volumes have been written, describing the habits of the various other genera of bees, and the construction of their different kinds of nests,—some of which are lined with the soft down of woolly-leaved plants,--others with the petals of roses or poppy-flowers. Some are built of solid masonry,--others excavated in wood,—whilst several species of bees are content to use the empty shells of snails, or even, cuckoo-like, to deposit their eggs in the nests of other bees; but these we must pass over, in order to be able to dwell more at length upon the economy of the hive-bee, the most interesting of the whole race.

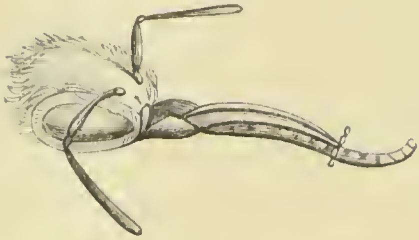
It is scarcely necessary to premise, that a community of hive-bees consists of three distinct kinds of individuals, each of which has its appointed duties,—namely, the *workers*, upon whom all the labours of the hive devolve; the *drones*, or male bees; and the *queen*, to whom alone is intrusted the continuance of the race, and who, therefore, is an object of constant care and attention.

The first thing to be done by a swarm of bees, on taking possession of a new hive, is to commence building chambers, in which to store their food and nurse the progeny on whom depends the future strength of the community,—a labour which, from its magnitude, might well appal the most resolute and industrious colonists, and tempt them to give up in despair an undertaking so vast, and apparently so disproportionate to the powers of the workmen. No time, however, is lost in idly contemplating difficulties; the work is instantly set about, and the numerous labourers at once begin to prepare materials wherewith to construct their waxen city.

The wax employed for this purpose is by no means so easy to procure as was supposed by ancient writers, who imagined that it was a vegetable production, which the bees had nothing to do but to collect from the flowers, and bring home ready for use; on the contrary, it is a material produced by the bees themselves, and that in very sparing quantities. Wax is, in fact, an animal secretion, which exudes from the skin of the insect, and, in the hive, is found lodged in little pouches, something like waistcoat pockets, which are placed upon the under surface of the abdominal segments, and which may easily be examined by slightly stretching this part of the body. In these pockets the wax is deposited in very thin layers, which the bee at once makes use of as material for building. With the wax thus furnished, and with nothing but their mandibles for tools, the little labourers now set to work with indomitable industry and perseverance; and notwithstanding that numbers of them are employed in the construction of every cell, they are never embarrassed in their operations, or deviate from the plan laid down for their direction by the Sovereign Architect.

The cells, be it remembered, are not cast in a mould, but are built piecemeal, by hundreds of bees, continually relieving each other; and as wax is progressively added to the advancing walls, it is a matter of no little trouble and difficulty to pare the sides to the proper degree of thinness, and to polish them as perfectly as they are found to be when completed. Numbers of wax-workers are therefore employed in finishing the interior of the cells, into which they may be seen to put their heads, and diligently scrape the walls with their mandibles, in order to remove every particle of superfluous material, which is at once carried away, the bee making it into a little pellet, and hurrying off to dispose of it elsewhere; but as another labourer immediately takes her place, the walls are by degrees reduced to their necessary thickness.

Fig. 62.



The cells of a comb are not all destined to the same use, some being employed for the reception of honey, some used as storehouses for "bee-bread," and others as cradles for the young brood. The latter, moreover, must be constructed to suit the different kinds of bees that are to be subsequently lodged in them. The male bees or drones are considerably larger than the working-bees, and of course the cells for their reception must be of proportionate dimensions, so that the labourers have to construct hexagonal cells of two different sizes, the number of each being in accordance with the respective numbers of working-bees and drones, afterwards to be deposited in them; and this difference is very considerable, the diameter of the cells for the reception of working-bees being two lines and two fifths, while that of the drone-cells is nearly three lines and one third; so that, obviously, the apartment suited for a labourer could never accommodate the larvæ of their larger associates.

Much has been said and written upon the subject of the geometrical shape which these cells present, and the reason of their form being invariable; and various have been the surmises upon this subject, put forth by different authors. It is to Reaumur, however, that science is indebted for the true solution of this question, than which, perhaps, a more clear and convincing illustration of Divine Wisdom cannot be adduced. That indefatigable observer, seeing the scanty provision of wax furnished by each of the cell-building bees, and feeling convinced that the shape of the cell was that best adapted to economize this precious material, proposed to M. Koenig, one of the ablest mathematicians of his day, the following problem:—"Amongst all possible forms of hexagonal cells, having a pyramidal base composed of three similar and equal rhombs, to determine that which could be constructed with the least expenditure of material." The mathematician undertook the solution of this very beautiful theorem, and at last demonstrated that among all kinds of cells with pyramidal bases, that would require the least quantity of material which should have its base composed of three rhombs, the angles of which should measure respectively, 109° 26′ and 70° 34′. M. Maraldi, another eminent naturalist, had in the meanwhile calculated, with as much accuracy as he was able, the real angles met with in the cell of the bee, which he had estimated, the former at 109° 28′, the latter at

70° 32′, leaving only two minutes of difference between the calculation and the result of measurement; and more recent researches, conducted with the delicate instruments of modern science, have shown even that slight discrepancy to be erroneous, and proved that the figures pointed out by mathematical research, and those adopted by the insect-labourer, are precisely identical.

The waxen walls of the cells having thus been completed, it still remains to give them a final polish, by varnishing them over with a peculiar material, called "propolis." This substance, which is a kind of resinous exudation, that besmears the opening buds of the poplar and other trees, is eagerly collected at the proper season, and smoothly laid on over the whole surface of the cell, where it in a short time dries, and becomes much harder than the wax itself, thus materially increasing the strength and firmness of the whole comb.

The cells may now be considered as finished, and our next business is to inquire concerning their number, and the uses to which they are converted.

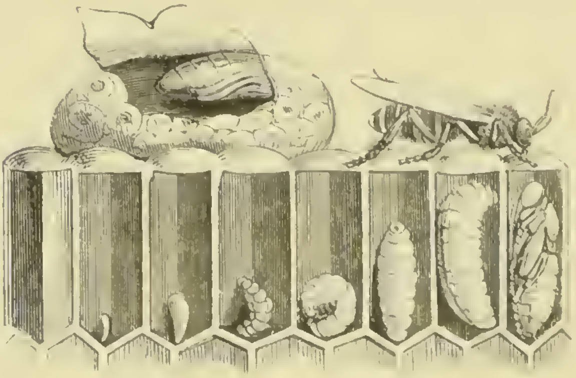
The number of cells constructed will, of course, be in accordance with the strength of the hive; but even in one of very moderate population, the amount of labour required in preparing these receptacles is truly astonishing. It has been calculated that in a piece of comb, fifteen inches long and ten inches broad, there were about nine thousand hexagonal cells; and seeing that their dimensions are similar in every hive, it is not difficult, having estimated the superficial extent of the combs contained in it, to assume their total amount with tolerable accuracy. So invariable, indeed, is the size of these cells, that it has been regretted that they were never adopted by the ancients as a standard of measurement; for as the length of the pendulum is referred to by modern scientific men, so could the dimensions of the cells of the honey-comb, had they been accurately ascertained by the Greeks and Romans, have given us positive data whereby to compare the measures used in their time with our own.

As fast as the cells are completed, they are used for the different purposes to which they are respectively adapted. Some are made stores for food, in which "bee-bread" and honey are industriously collected, during the time of flowers, as provisions for the commonwealth.

The substance called "bee-bread" seems to constitute the ordinary nourishment of the working-bees. It consists of the farina or pollen of flowers, which the labourers collect in the little cavities or pollen baskets, situated upon their hind legs. When these baskets are filled with as much pollen as the bee can conveniently carry, she flies back to the hive with her valuable load, where she is speedily disencumbered of her burden by the assistance of her fellow-workers. The pollen thus procured is at once kneaded and packed close in cells provided for its preservation. The quantity of "bee-bread" collected, considering the size of the little insects, and the trouble of collecting and transporting it, is astonishing, and has been calculated at a pound's weight a day for a single hive, during favourable weather; so that a hundred-weight of this material may be imported, by the labours of these indefatigable collectors, during the brief season available for this necessary work. Besides the quantities of pollen thus diligently collected, another, and, to us, more interesting store of nutriment, is at the same time obtained from the flowers, namely, the honey, with which the bees fill a considerable proportion of the cells of their comb. This delicious product of the hive is obtained from the sweet juices of flowers. These the bee laps up by means of her long and flexible tongue, until she has filled her crop or honey-bag with the sugared fluid; and in this cavity, as in a laboratory, the nectar is soon transformed into pure honey, which, on returning to the hive, is regurgitated into one of the honey-cells.

The honey-cells provided for its reception, appear to be fitted in regular order, beginning with those nearest the top of the hive; and no sooner is a cell completely filled by the united labours of many

Fig. 63.



workers, each of which contributed a drop or two of honey, than it is carefully sealed up with a waxen covercle, and left for future use. There is, however, a difficulty connected with the performance of even this apparently simple operation, which must not be altogether overlooked. The combs in the hive are all arranged vertically, so that the cells which have to be filled with honey, are necessarily placed in a horizontal position; and although to fill a jar with honey may seem easy enough whilst the jar is upright, it might puzzle an ingenious housewife to fill the same jar when laid flat on its side; and yet this is what the bee must literally accomplish, and the task becomes still more difficult when we remember that many bees have to come in succession, to pour their honey into each cell.

The manner in which this part of the process is accomplished is as follows. On attentively examining the contents of a comb only partially filled, it is easy to perceive that the stratum of honey nearest the mouth of the cell, differs from the rest, both in consistency and colour, as much as cream differs from the milk on which it swims. The proceeding is therefore simply as follows. The bee, wishing to add its honey to the general stock, enters the cell, head first, and, perforating the creamy lid by means of its fore feet, pours in one or two drops of honey, and immediately readjusts the creamy pellicle, which, aided by the viscidity of the honey and the attraction of the walls of the cell, thus permits it to be filled even to its very margin.

Having thus examined the ordinary labours of the working-bees, and the process of storing the provision-cells with food, we must now turn our attention to the *nurseries* of the hive, and the proceedings of the queen-bee and her attendants, whilst providing for the numerous progeny to which she gives birth. The fertility of the general mother of the colony is indeed prodigious, and the preparations that have to be made for the accommodation of her offspring proportionately extensive. Reaumur roughly estimated the number of cells in a hive which he examined, at about fifty thousand; and of this number, upwards of twenty thousand were already occupied with brood, that is to say, contained either eggs, larvæ, or pupæ, in different stages of growth; nevertheless, on examining the parent queen, by whom all these eggs had been laid, and which was killed by accidental violence, she was found to contain probably as many thousand more. When, therefore, it is considered that most of the bees already at work in the hive, amounting in number to twenty-eight or twenty-nine thousand, in addition to the twenty thousand still imprisoned in their cells, had all owed their birth to the same individual, and who was obviously still capable of producing as many more, we may well be astonished at such wonderful fecundity.

Of the above number of brood-cells, about two thousand five hundred were constructed for the reception of drones, or male bees, all of which are destined to be massacred in a very short time after they attain their mature condition.

No sooner are a few cells prepared by the working-bees, in which their queen may lay her eggs, than she begins the work of oviposition, passing from cell to cell as fast as they are ready for her, and depositing an egg in each,—drone-eggs in the drone-cells, worker-eggs in the worker-cells,—she leaves them to the care of her attendants, who anxiously accompany her during these important visits to the different parts of her dominions. In the course of two or three days from their deposition, these eggs are hatched, giving birth to a worm-like larva (fig. 63) or grub, which is perfectly destitute of limbs, and so helpless, that it would speedily perish, but for the constant and assiduous attention bestowed upon it by the working-bees.

From the time of its being hatched, up to the period of its first metamorphosis, the grub remains rolled up at the bottom of the cell (fig. 63), which, from its pyramidal form, seems but little adapted to make it comfortable; on close examination, however, it is found to be more snugly lodged than it at first appears to be,—being laid upon a couch of a whitish gelatinous substance, which not only forms its bed, but affords it nourishment during the earlier days of its existence. As it grows larger, it remains quite incapable of helping itself, but is nevertheless abundantly provided with everything necessary for its subsistence. Many times, in the course of the day, it is visited by careful attendants, who supply all its wants, and give it food, adapted to its condition, composed of a gelatinous paste sweetened with honey, the proportions in which the two are mixed being apparently altered from day to day, as the digestive powers of the young nurslings increase in vigour.

At length the bee-grub grows so large, that its coiled-up position becomes inconvenient, and it straightens itself, the more fully to occupy its cell, until the time at length arrives for its first metamorphosis. The nursing-bees, which had hitherto so unremittingly supplied the young grub with food, now leave off feeding it. They know that it has no longer need of eating, and consequently they only employ themselves in defending it from disturbance during its quiescent condition, which they accomplish by constructing a waxen cover to the cell, sealing it firmly down, and leave the object of their former care shut up in what might well seem its tomb.

But no sooner is the grub thus abandoned apparently to starvation, than it begins to exert itself and assume new capabilities. It had previously been able to do nothing but eat; it is now compelled to begin to work, and its first employment is to line all the interior of its cell with silken tapestry, produced exactly in the same way as the cocoon of the silk-worm, but constructed of a finer material, and woven more closely. So accurately is this silken covering fitted to the walls of its cell, that it is not easily perceptible, except upon close examination. Having completed its cocoon, the grub casts its old skin, and assumes the pupa condition, all the parts of the future bee being easily traceable on its exterior, although they are as yet encased in the usual envelopes (fig. 63).

When all its parts have attained their complete development, the pupa is ready once more to change its condition, and to make its appearance under the form of a bee. It begins its metamorphosis by divesting itself of the thin membrane which, like a white veil, shrouds all its external limbs, and, having set itself free, prepares to burst through the gates of its waxen prison, and enter upon an active state of existence. For this purpose it avails itself of its newly acquired jaws, with which it pierces through the lid of its cell, and having once made a hole, soon succeeds in enlarging it sufficiently to protrude a portion of its head; and at length, after three or four hours' labour, it is able to scramble out of the cell, a fully formed bee.

The workers of the hive, as soon as they perceive their newly born fellow-labourer, surround her in the most friendly manner, and seem to testify their welcome by numerous little attentions, smoothing her coat with their trunks, and presenting her with honey. No sooner are all the limbs of the young worker sufficiently firm, and her wings dried and expanded, than she seems to understand exactly everything that she has to do during the rest of her life.* She appears to know at once that she is born for her community, and that important labours devolve upon her. She walks about over the courts as though examining their arrangement, and at length seems to wish to visit the world without. Numbers of bees are ready to show her the gates of the hive, and further guidance she does not require; she flies like the others from their common citadel in search of flowers,—nay more, she goes alone, selects the proper plants without assistance, and when she returns to the hive, even for the first time, has not the slightest difficulty in finding her way back, loaded with provisions, to add to the general stock, and ready to perform all the duties of her new station.

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* "Qu'on ne s'étonne pas," says Reaumur, "qu'elle soit si bien instruite et de si bonne heure; elle l'a été par celui même qui l'a formée."

In the above account of the metamorphosis of the bee-grub, we have, for the sake of perspicuity, confined our attention to a single individual; we need, however, scarcely remind the reader that the same scene is simultaneously in progress throughout the whole series of the nursery-cells; and as each bee makes its escape as soon as it has arrived at maturity, a hundred or more are added to the community every day. The cells from which these emerge are, moreover, by no means done with, but, on the contrary, are destined to be the cradles of consecutive members of the family; for, be it remembered, that the queen is constantly employed in laying her eggs as long as cells are at her disposal for that purpose. No sooner, then, has a new-born bee burst its cerements and got free, than the cell which it has just abandoned is immediately visited by the watchful labourers, and prepared for the reception of another egg. The former occupant, as we have seen, must have left behind it the two coverings which it had successively cast off, one having been its larva skin, and the other its investment during the pupa state. This seems well understood by the old nurses, one of whom soon enters the cell, and seizing the pupa-skin with her jaws, drags it out and carries it away; another nurse succeeds the former in search of the larva-skin, which is removed in the same manner; and lastly, many other workers enter the cell, one after another, for the purpose of clearing away the broken particles of wax or other foreign bodies, until the cell is thoroughly cleansed. The silken tapestry, however, woven by the former occupant, is left untouched, as, instead of being in the way, it renders the walls stronger and more compact. Cells have been observed which, in this way, have been successively occupied by five different tenants, each of which of course added to the thickness of its silken lining; and the comb, thus strengthened, is at last converted into a depository for honey.

Amongst the numerous progeny thus added to the population of the hive, a very considerable number are males, or drones, which, as has been stated, are educated in larger cells than the working-bees, and attended upon by the nurses with equal care and affectionate solicitude. No sooner, however, has the presence of the males become unnecessary, and the young queen, who has selected her mate from amongst them, treats them with indifference, than her followers declare a most cruel war against all the male inhabitants of the hive, and a scene of slaughter commences, unparalleled, except, perhaps, in the annals of human massacres. In spite of their superior size, the males are quite helpless against the attacks of the workers, whose poniards are armed with mortal venom. They are, moreover, overwhelmed by the numbers of their assailants, each drone being attacked at once by three or four of his exasperated foes, who were recently so kind and attentive to his wants. During three or four days the carnage is unrelentingly carried on, and from morning till night the workers may be seen dragging out of the hive the dying or the dead victims of their rage. Even those males who have not yet assumed their winged condition, but remain still immured in their waxen cradles, are not spared, the workers tearing them from the very cells which they themselves had been at so much pains to prepare for them, and where they had fed them with such tender assiduity. The hatred of these Amazons extends to the whole male sex, whether babes or adults, and not one, either young or old, escapes the terrible slaughter.

We have at present only spoken of the growth and education of the labourers, and of the drone-bees, and have still to lay before the reader the history of the third kind of progeny, to which the queen of the hive gives birth. The thousands of unfertile workers, and the males, so soon destined to destruction, all belong to the same generation; and as none of these ever can become mothers, it is essential that some of the eggs laid by the queen should produce prolific females, through whose instrumentality the race may be perpetuated. She does in fact lay eggs of this description, and the working-bees seem to be quite aware of their superior importance, and construct cells specially appropriated to their reception. These cells are, moreover, not, like those of the males, simply of larger dimensions than ordinary, but they are built after a totally different plan,—the bees laying aside altogether their accustomed rules of architecture, when employed in constructing the habitations of the royal family. These state apartments are indeed very different from the hexagonal cells; and although their shape does not please us so well, their appearance may perhaps seem more magnificent in the estimation of the insects that construct them. Their form is rounded and oblong (fig. 63), one end being larger than the other, while the outer surface is covered with little hollows. If the bees, however, do not seem to have aimed at elegance and symmetry in the construction of the regal abodes, they appear at least to be attentive to the strength and substantiality of their masonry. Their wax, which is expended with such jealous economy in building the hexagonal cells, is here used with extravagant profusion, as though nothing was too costly for the work,—the weight of the material employed in the construction of a single royal palace being from a hundred to a hundred and fifty times more than is required to complete the residence of a worker.

Neither are the bees at all anxious to economize room whilst laying out the plan of a royal chamber, for not unfrequently it is found placed upon the middle of a comb, as though for the purpose of obtaining a conspicuous position for it; and many common cells are sacrificed for the sake of forming a basis on which to support its weight. The usual situation of the queen-cells is upon the lower margin of a comb, from which they hang like stalactites from the roof of a cavern.

In each of these remarkable apartments the mother-queen lays an egg, from which will be hatched the embryo of a fertile female; and it might even seem that the working-bees know before-hand how many royal eggs their queen was going to lay, so as to prepare the exact number of cells required. Truly, as Reaumur says, "*Elles savent tant de choses quelles pourroient bien encore savoir cela.*" However this may be, as the same author assures us, they construct just as many as she requires, although the number varies considerably, two or three only being found in some hives, whilst in others there are as many as thirty or forty.

Another important difficulty still remains to be surmounted. Notwithstanding the number of royal cells thus constructed, all of which contain embryos from which fertile females will be produced, no law of Nature seems to be more rigidly enforced than that which restricts the sovereignty of the bees to a single individual. The world, as we are told, could not endure two suns, or two Alexanders; neither could the discipline of the hive allow of the co-existence of two queens. Every precaution has therefore been taken to prevent such an occurrence, —precautions for the knowledge of which we are indebted to the careful observations of Huber, whose account of their proceedings we shall condense, from the interesting pages of Kirby and Spence.*

We have already observed that the number of royal cells in a hive varies from two or three to thirty or forty, but usually there are not less than sixteen, and sometimes not fewer than twenty,—in all of which embryo queens have been deposited by the general mother of the community, but of which one only is destined to be the future monarch of her native hive. In some instances, a single queen only is wanted to take the place of her royal parent; in others, several are required to lead the different swarms, which at successive periods migrate to form new colonies. In the first case, inevitable death is the lot of all but one; in the other, as many as are wanted are preserved from destruction by the precautions taken by the workers, under the direction of an all-wise Providence. Did the mother-queen remain in the hive till the young ones were ready to come forth, her instinctive jealousy would lead her to attack them as successively produced; and being so much older and stronger, the probability is that she would destroy them,—in which case there could be no swarms and the race would perish. But this is wisely prevented. The first swarm is conducted by the original queen, and not by a newly disclosed one, as Reaumur and others have supposed. The royal cells, be it remembered, in which her queen-brood is deposited were not all built in one day, but at distinct intervals—a considerable time thus elapses between the laying of each queen-bearing egg—a most essential provision, in consequence of which the queens come out successively in order to lead successive swarms.

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* Vol. ii. p. 140, et seq.

Before the first-born new queen makes its appearance, the old monarch prepares for her departure from the dominions over which she has so long reigned, and gathering together such of her subjects as are destined to accompany her — a multitude amounting in number to from twelve to forty thousand, and composed indiscriminately of both old and young working bees—she sets out in search of a fit locality where to found a new colony.

Scarcely has the old queen taken her departure, than her destined successor, or, in other words, the queen which first escapes from her confinement, proceeds to secure her right to the throne by an act of tyranny which might seem truly barbarous did we not understand the necessity which compels her to the deed. Rushing at once to the royal cells, which still contain nascent queens, she darts with fury upon the first she comes to, and having, with her jaws, gnawed a large hole in its walls, through which to attack her victim, soon dispatches her, before she can defend herself or resist the attack. The workers, who remain passive spectators of this assassination, then enlarge the breach which she has made, and drag forth the carcase of a queen just emerged from the thin membrane that envelopes the pupa. If, however, the object of her attack be still in the pupa state, she is stimulated by a less violent degree of rage, and contents herself with making a breach in the cell : when this happens, the death of the inclosed insect is equally certain, for the workers soon enlarge the breach, pull out the royal infant, and it perishes. If it happens, as it sometimes does, that two queens are disclosed at the same time, the care of Providence to prevent the hive from being wholly despoiled of a governor is singularly manifested by a remarkable trait in their instinct, which, when mutual destruction seems inevitable, makes them separate from each other as if panic struck.

"Two young queens," says M. Huber, "left their cells one day almost at the same moment. As soon as they came in sight, they darted upon each other as if inflamed by the most ungovernable anger, and placed themselves in such an attitude that the antennæ of each were held by the jaws of its antagonist—head was opposed to head, trunk to trunk, abdomen to abdomen—they had only to bend the latter and they would have fallen reciprocal victims to each other's sting; but Nature having decreed that these duels should not be fatal to both the combatants, a panic fear seemed to strike them—they disengaged themselves, and each fled away. After a few minutes had elapsed, the attack was renewed in a similar manner, with the same issue; till at last, one suddenly seizing the other by her wing mounted upon her, and inflicted a mortal wound."

If several queens are introduced into a hive, all but one must perish, and that one will have won the throne in personal combat, by her own unassisted valour and strength.

Another remarkable display of instinct, is of equal importance to the welfare of the community. While the new queen is thus inveterate in her hostility to all rivals, whether new-born or in the pupa state, she never attacks those royal cells of which the inmates are still larvæ, which latter are thus allowed peacefully to come to maturity, in order that they may take the command of the next swarm, and when several successive swarms are to issue from the hive, each of which must have a queen, extraordinary precautions are necessary to ensure their safety.

The treatment and defence of the young queens that have to lead the swarms, devolves upon the working bees, whose sagacity upon such an occasion is wonderfully conspicuous. Were a queen permitted to leave her cell as soon as the natural term for it arrived, it would require some time to fit her for flight, and to enable her to lead forth a swarm; during which interval a troublesome task would be imposed upon the workers, who must constantly detain her a prisoner to prevent her from destroying the other queens. On this account they never suffer her to come forth till she is perfectly fit to take her flight. When at length she is permitted to do this, if she approaches the other royal cells, the workers on guard seem greatly irritated against her, and pull and bite and chase her away, so that she enjoys tranquillity only when at a distance from them. At last she becomes violently agitated, and communicating her agitation to others, the confusion increases more and more till a swarm leaves the hive, which she either precedes or follows.

The necessity that exists for thus strictly limiting the number of queen bees to a single individual for each swarm is, of course, attributable to their enormous fertility, for it would seem to be quite incompatible with the general safety were not such exuberant fecundity jealously limited. But, on the other hand, a danger equally great has to be provided against, for were any accident to cause the destruction of the solitary monarch of the hive before she had laid eggs for the production of future queens, her successors, all hopes of perpetuating the race would vanish. Yet even this contingency has been foreseen. No sooner are the inhabitants of the hive thus left without a fertile female, than, taught by Supreme Wisdom, they set about repairing their seemingly irremediable loss, and, selecting a few of the larvæ which would, in ordinary course, have become mere labourers, they feed them with food of a richer and more stimulating quality than would have been allowed them under other circumstances, and simply by affording this improved diet, to otherwise unprolific larvæ, they are converted into breeding-queens, of which the first matured becomes, at her birth, invested with all the privileges and labours attendant upon the regal office, and thus the danger is averted, and the perpetuation of the colony insured.

CHAPTER XIII.

STREPSIPTERA.—XENOS AND STYLOPS.

Among the discoveries of modern times, one of the most startling to the entomologist has been that of the race of insects which we must next introduce to the reader's notice, and which are not less remarkable for their extraordinary conformation than for the singularity of their habits.

In the structure of their wings the Strepsiptera differ so widely from all other insects, that as it was found impossible to class them with any of the orders established prior to their discovery, they were, necessarily, grouped together as forming an order by themselves, distinguished by the following characters.

The first two segments of the thorax (the prothorax and mesothorax) are extremely small in proportion to the size of the insect, while the hinder segment (the metathorax) is, on the contrary, immensely developed—an arrangement which corresponds exactly with the condition of the wings, the anterior pair of which, attached to the mesothorax, are quite rudimentary in their development, so much so, indeed, that they have been denied to represent wings at all, and have had the names "præhalteres," "pseudhalteres," &c., applied to them by different authors; while the posterior pair, attached to the metathorax, are very large, their shape, when expanded, representing the quadrant of a circle, and containing but a very few longitudinal veins, which are so disposed that the wing, when not in use, folds up exactly like a fan, and are thus laid along the sides of the body. From the peculiar curved and twisted appearance of the anterior pair of wings, Mr. Kirby proposed for this newly established order of insects the name of STREPSIPTERA (στρέφω, στρέψω, and πτερόν, meaning twisted wings), while other entomologists, who denied that the anterior pair were wings at all, preferred the name RHIPIPTERA (ῥιπίς, a fan, πτερόν, a wing), indicative of the manner in which the metathoracic wings are folded up.

The habits of these insects are not less remarkable than their structure. In their early states they are only found living parasitically in the bodies of various genera of *Wasps* and *Bees*, which, when thus infested, may be known by their unwieldy and distorted appearance; or, when the larvæ are full grown, they may be seen protruding their heads between the abdominal segments of the wasp or bee, as though quietly taking a survey of the world around them.

All the known examples of this order of insects are referable to two genera, named respectively Stylops and Xenos. Their larvæ are cylindrical fleshy grubs (fig. 64), of about a quarter of an inch long, of a white colour, with the head distinct and flattened, and attached to the body by a narrow neck. They seem to live, at first, entirely buried in the abdomen of the bee or wasp, where, however, they carefully avoid injuring any of the vital organs. When the feeding state is passed, they are supposed, by means of their flattened heads, to pierce the membrane which connects the abdominal rings, and are found with the fore part of their bodies protruding through the aperture.

The Rev. Mr. Kirby,* who first discovered these strange parasites, at first mistook them for mites, with which bees and other insects are sometimes infested. "What was my astonishment," says he, "when, upon attempting to disengage one of them with a pin, I drew forth from the body of the bee a white fleshy larva, a quarter of an inch long, the head of which I had mistaken for an acarus. How this animal receives its nourishment seems a mystery. Upon examining the head, under a strong magnifier, I could not discover any mouth or proboscis with which it might perforate the corneous covering of the (bee's) abdomen, and so support itself by suction: on the under side of the head there was a concavity, but I could observe nothing in this but a uniform unbroken surface. As the body of the animal is inserted into the body of the bee, does that part receive its nutriment from it by absorption? After I had examined one specimen, I attempted to extract a second, and the reader may imagine how greatly my astonishment was increased, when, after I had drawn it out but a little way, I saw its skin burst, and a head as black as ink, with large staring eyes and antennæ consisting of two branches, break forth and move itself briskly from side to side. It looked like a little imp of darkness just emerging from the infernal regions."

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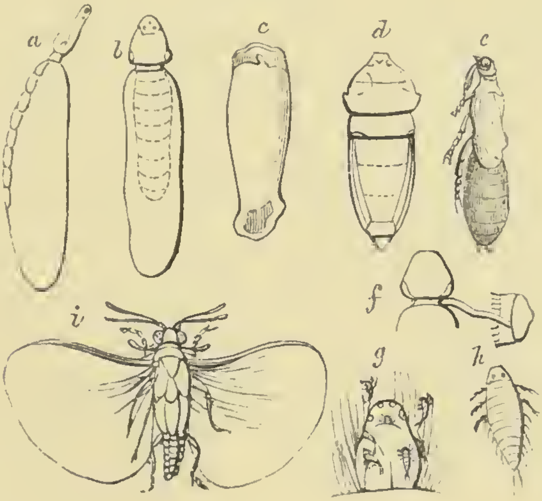
* Monograph. Apum Angliæ, vol. ii. p. 111.

These singular parasites are apparently without any jaws, so that the way in which they feed themselves is still a problem to entomologists. After changing its skin in the same way as other insects,

Fig. 64.



the larva becomes a pupa (fig. 64), from which at length the perfect insect (fig. 64 *i*) emerges. Dr. Siebold, of Erlangen, has recently prosecuted inquiries relative to these remarkable parasites of the Hymenoptera, with great care, and thrown considerable light upon their singular history. According to this distinguished observer, the metamorphosis of the female stylops is very different from that of the male which is represented in the above figure, the females never obtaining either legs, wings, or eyes, but continuing to resemble larvæ in their appearance, and never quitting the bodies of the Hymenoptera, in which they are parasitic. Before the publication of Dr. Siebold's researches, Mr. Westwood had noticed another set of insects inhabiting stylopised bees, which he believed to be a distinct race, and of which he gives the following account :—

" In the spring of 1836," says the indefatigable entomologist alluded to, "whilst keeping numerous stylopised individuals of Andræna gynnana and parvula (two species of a genus of hymenopterous insects nearly allied to bees), in the hopes of rearing the stylops, I observed a number of excessively minute hexapod creatures, creeping amongst the hairs of the abdomen of the bees (which were evidently much annoyed at their presence), and which, with a strong lens, I distinctly saw making their way through the transverse impression near the extremity of the upper side of the head of the larva of the stylops, and in this manner every one of the many larvæ of stylops, which I hoped to rear, perished. Anxious, however, to obtain more knowledge of these parasites of the parasite, I opened the bodies of some of the bees thus attacked, so as to expose the moist and fleshy bodies of the larvæ of the stylops, when I was surprised to find the latter filled with an extraordinary number of them; some, as though not sufficiently developed, lying in an arched position, and others nearer the head of the stylops larva, struggling towards the place of exit above mentioned. The transparent skin of the larva permitting them to be clearly visible, I do not hesitate in stating that there must have been far beyond a hundred of these creatures in each stylops larva."

From Dr. Siebold's researches it appears that the footless grub-like beings, which Mr. Westwood and earlier observers naturally enough looked upon as larvæ, are, in reality, the mature females—which are viviparous, and never quit the bodies of the Hymenoptera to which they are parasitically attached—and that the little hexapod creatures above described are, in reality, the young Strepsiptera, which, when they quit the eggs in which they are developed within the body of their parent, are furnished both with legs and a mouth. After their birth, these little hexapodous larvæ infest the surface of the abdomen of the bees, within which their parent-mothers live and die, and in this way the young stylops is conveyed into the nests of the Hymenoptera, and getting access to the larvæ, becomes parasitic on them, as its parent was in the bodies of the adult bees.

"The presence of these parasites," Mr. Westwood observes, "is at once indicated by the swollen and distorted appearance of the abdomen of the bee or wasp thus attacked. Generally two or three parasites are found in each infested insect, but sometimes there are as many as five or six. They do not destroy the bee or wasp, since they never attack its viscera, but live entirely upon the fat stored up within its body: nevertheless, it is more than probable that the insects, which seem to be generally females, are rendered incapable of laying eggs by the presence of such intruders, and thus, like the Ichneumons, the Strepsiptera may be important agents in preventing dangerous excess of fertility in the races that they infest."

CHAPTER XIV.

APHANIPTERA.

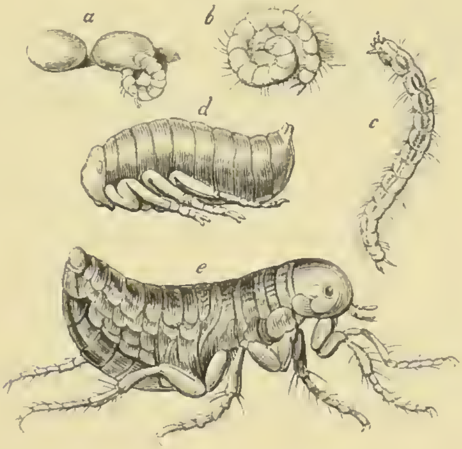
ONCE more let us congratulate ourselves upon the minute size of our insect persecutors, which at every step present themselves under some new aspect, only requiring dimensions proportionate to the perfection of their structure, to become monsters more terrific than "fables yet have feigned, or fear conceived."

Fleas are generally supposed to have no wings, and even by scientific entomologists have been placed among the very miscellaneous list of apterous insects. It is true that they have no power of flight, nor any organs adapted to effect such a mode of locomotion; nevertheless, a close examination shows that they are not altogether devoid at least of rudiments of such limbs, for, attached to the middle segment of the thorax, it is not difficult to detect a pair of small immovable scales which are the representatives of the anterior wings in other insects, while the posterior thoracic segment is furnished with two similar scales of still larger dimensions, which are analogous to the hinder wings of the four-winged races. The term *Aphaniptera,* therefore, indicating that although possessed of wings, they do not appear to be so, is by no means inapplicable to the order under consideration. But while thus destitute of the means of flight, which to creatures living under the circumstances to which they are destined, would be not only useless but positive encumbrances, they are singularly adapted, in every point of their structure, to occupy a territory, too rich in food to be left without insect inhabitants, and yet so difficult of access that no ordinary labourers could ever make their way amid the trackless wilds of their settlements. The dense and tangled jungle through which they have constantly to travel, is formed of the thickly interwoven hairs of various species of quadrupeds, amongst whose fur they live; and it is to enable them to force their way amid such obstructions that they are provided with the peculiarly-shaped limbs they possess, and gifted with muscular power that, even among insects, is extraordinary.

The female flea lays about a dozen oblong eggs, of a dirty white colour, which are deposited in old rugs, dark chinks, or similar localities. The larvæ (fig. 65 *b c*) proceeding from these are minute, worm-like grubs, quite destitute of feet, but all furnished with two hooks, situated at the posterior extremity of their body. These little grubs are extremely active, feeding, it is said, upon such substances as the fleshy part of feathers and the blood of animals, until they attain their full growth, said to be in summer time about twelve days after they are hatched. Before entering upon the pupa condition, the young flea encloses itself in a little silken cocoon, which it constructs in the same way as other silk-spinning larvæ, attaching it to some foreign body, where, from its being covered with dust, it is not easy to detect its presence.

The pupa (fig. 65 *d*) is quite inactive, but its legs are visible externally, each being encased in a separate sheath ; in this condition it remains during a period varying from eleven to sixteen days, when the perfect insect makes its appearance, armed with formidable lancets instead of jaws, and thirsting for the blood of unsuspecting victims.

Fig. 65.



For the benefit of such of our readers as may not wish to study more practically the habits of these active marauders, we copy a receipt prescribed by old Tusser, as an effectual safeguard :—

> " While wormwood hath seed get a handful or twaine,
> To save against March to make flea to refraine ;
> Where chamber is sweeped, and wormwood is strown,
> No flea for his life dare abide to be known."

The chigoe, or jigger (*Pulex penetrans*), is another species of flea, unfortunately of but too common occurrence in tropical climates. In South America, and the West Indies, more particularly, this insect, notwithstanding its insignificant size, becomes truly formidable from the insidious mode of its attack, and the difficulty of getting rid of it when once it has secured a lodgment. Mr. Westwood gives the following summary of the history of this dangerous parasite, gathered from the published accounts of various authors:—"The jigger lives in the open country, and during the dry season multiplies incredibly in sandy and dusty places. It chiefly attacks the naked feet both of men and dogs, particularly between the toes and under the nails, burying itself deep into the skin, and occasioning, by its constant irritation, the most violent indisposition, inflammation, swellings, ulcers, and even death. After one of these insects has effected a lodgment in the skin, its body becomes enormously increased in bulk, acquiring the size of a pea, but this enlargement is entirely due to the distension of the abdomen, which is filled with an immense number of eggs, and in this state the greatest care is requisite in endeavouring to extract the insect to get it out entire. The specimens which thus burrow into the flesh are, therefore, evidently impregnated females, for no author has noticed the discovery of larvæ or pupæ in the feet or elsewhere. If left unmolested, the most dreadful consequences not unfrequently ensue—fearful ulcers are formed, which not unfrequently extend to the bones, and sometimes render amputation necessary. From their vast numbers, however, it is evident that their ordinary development must take place elsewhere than in the foot."* According to authorities quoted by Kirby and Spence, it is not, however, to the feet alone that the chigoes confine their attacks, but they will establish a settlement in the legs or hands, or any other exposed part of the body, and, moreover, they prefer the flesh of a newly-imported European to that of a Creole, or of a person born in the climate.

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* Westwood, Introduction to Modern Classification of Insects, vol. ii. p. 494.

CHAPTER XV.

DIPTEROUS INSECTS.

We now have arrived at the last, but by no means the least extensive division of the insect races, which comprehends all those possessed of only two wings, representing the anterior pair of the preceding four-winged orders, the hinder wings being replaced by a pair of remarkable organs, called the *halteres* (poisers or balancers). They are all suctorial in their habits, their mouth consisting of a very singularly constructed proboscis, or sucker, to which several lancet-like organs are appended,—frequently used, much to the annoyance of mankind and other animals.

The gnat, the mosquito, the daddy-long-legs, and the common house-fly, are familiar examples of this order; but common as these insects are, how few are acquainted with their wonderful history, and fewer still appreciate the importance of the duties that devolve upon them.

Considered isolatedly, no creatures could be in appearance less formidable than the insects we are about to describe, or less adapted to act an important part in the economy of this world; and yet, when rightly understood, it is scarcely too much to assert, that they will be found to constitute the main pillars whereby the vast fabric of creation is sustained,—the most active, the most indefatigable, and the most universally employed of all the winged messengers employed in the grand police of Nature.

Various and widely different from each other are the duties assigned to each race; but untiring in their energies, punctual to their seasons, and ever at their posts, these insect legions work unseen and unnoticed; no matter how low or despicable the drudgery that may fall to their lot, it is continually and faithfully accomplished; and, as in a well-ordered family, the elegance and comfort which everywhere meet the eye, are mainly attributable to the unseen labours of domestic life, so, in the economy of this world, whilst nothing is conspicuous but loveliness and beauty, so much order and regularity can only be maintained by the unobtrusive but unwearying diligence of hosts of menials, whose exertions are essential to the wellbeing of the whole.

Here, however, we must again remind the reader, that in the imago or winged condition, the insect is by no means in its most efficient state of existence, but on the contrary, that its "dirty work" is got through whilst wearing a very different dress from that in which it offers itself to public inspection.

No feature of creation is more calculated to arrest the attention of the observer of Nature than the extreme cleanliness which is everywhere conspicuous, and that under circumstances of difficulty which few take the trouble to appreciate. How vast the slaughter constantly in progress among living animals! How immeasurable the work of death, which, hour after hour, continues to strew the surface of the earth with multitudes of inanimate carcases, left by their decomposition to taint the atmosphere and pollute the ground! A moment's reflection must at once convince us that, were there not agents continually and untiringly at work, to remove the accumulating heaps of carrion, the mighty nuisance would soon become intolerable, and pestilence and disease reign triumphant, where all is now purity, and health, and vigour.

Silently and almost imperceptibly the work goes on; but the scavengers are continually at their labours; the wreck is unceasingly removed as fast as it is deposited; putrefaction and decay are speedily banished; the footmarks of the destroyer obliterated, almost as soon as they are impressed; so that, in spite of the appalling devastation, "the world runs merry as heretofore."

As might easily be expected from their numbers and activity, the insect races have a large share in this great work, and from every regiment of their vast army, detachments are commissioned specially to co-operate in the cleansing process.

No sooner does an animal die than these flying emissaries hasten to the spot, and, under innumerable forms, either simultaneously or in succession, begin their labours; but first and most conspicuous, both in zeal and efficiency, are the members of the great family of flesh-flies (*Muscidæ*), whose habits and instincts in every way adapt them to the discharge of their important duty.

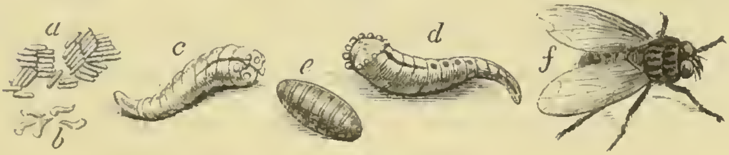
Linnæus hazards the somewhat startling assertion, that three flesh-flies will eat up the carcase of a horse sooner than it would be devoured by a lion; and after a little reflection, the most sceptical must admit that this statement is literally correct. The monarch of the desert, it is true, may gorge himself with the flesh of his prostrate victim, but, however ravenous he may be, satiety soon puts a stop to the meal, and he must remain inactive until the return of appetite once more puts him in a condition to prosecute the work; but the progeny of the little flies, labouring incessantly, in continually augmenting multitudes, have no need for stay or rest; and before their hungry myriads, which labour both by night and by day, the bulk of the carrion soon disappears.

The first detachment of these scavengers which is despatched by Nature to the scene of action (*Sarcophaga carnaria*), affords abundant proof that no needless delay can be allowed in commencing a work of so much importance to the general welfare. Other insects, as we have seen all along, lay eggs; and days, or weeks, or months elapse before their eggs are hatched, and living larvæ make their appearance; but no such lengthened inactivity can be permitted in the case of these flesh-devourers. Laying aside the usual mode of procedure, the *Sarcophaga carnaria* arrives, loaded with eggs ready hatched, and at once disburdens herself of an army of twenty thousand active and voracious maggots, impatient to begin the abundant banquet which awaits them. Their appetites are not at all out of proportion to the liberality of the supply of food, nor is the rapidity of their growth limited by the rules generally applicable to other animals. It has been proved by experiment, that in the short space of twenty-four hours, these larvæ will increase in weight upwards of two hundred fold; so that, whilst it requires twenty-five or thirty of the new-born maggots to make up a grain in weight, each of these, by the same hour on the following day, will weigh seven grains; and with such rapidity do they pass through the different states of their existence, that they would soon be able to give birth to other legions, if their assistance should be wanted to complete the work; but this can rarely be necessary. Indeed, the principal reason for so much haste in hurrying them through the larva state, would seem to be that, were they longer than four or five days before they assumed the chrysalis form, they would perish for lack of food, and die of famine produced by their own voracity.

They are, however, by no means the only workmen employed to insure the speedy completion of the important work. The common meat-fly (*Musca Cesar*) no sooner scents the tainted atmosphere, than she hastens to secure a share of the booty, covering the dead animal with multitudes of eggs, which, being hatched in the course of a few hours, produce as many hungry mouths, eager to set to work;

whole tribes of carrion beetles quickly join the busy multitudes, and thus, by the united efforts of so many labourers, the mass of garbage is removed with inconceivable rapidity. Even the bones are scrupulously cleaned, for wasps and ants complete the work; and by removing the last particles of flesh, leave nothing but the skeleton, which soon becomes the prey of other jaws.

Fig. 66.



When the maggots of the flesh-fly have attained their full growth, they no longer find in the putrid flesh, on which they had previously luxuriated, a commodious residence, and soon prepare to quit it, in order to look out for some more enduring secure retreat. Leaving remnants of the rotting carcase, they wander about in search of some loose soil, adapted to their purpose, and, having found a fit locality, bury themselves in the ground to a considerable depth, where they remain two or three days without eating, preparatory to entering upon the pupa condition.

At the end of two or three days, the maggot, which was originally a white, tender, soft, and fleshy worm, shrinks into an oval shape, and, becoming of a reddish or chestnut colour, soon appears encased in a hard crustaceous envelope, of such firm texture, that it is no longer able either to elongate, or shorten, or dilate, or contract its body, but becomes perfectly stiff and motionless; in a word, instead of having the appearance of a living animal, it looks just like an egg.

The insect, however, still continues to live, and the changes as yet noticed are of a very slight character, in comparison with those that are still in progress. These maggots, it will be observed, spin no cocoon, in which they may be protected during their helpless condition; nevertheless, a defence has been provided for them, which is even still more wonderful in its nature. It would be esteemed no small prodigy, observes Reaumur, if we were informed that there was a quadruped of any description, such as a bear or an ox, which at a certain season of the year, on the approach of winter for instance, entirely detached its skin from its body, in order to convert it into a sort of box, in which to encase itself, and that it was able not only to close up this box on all sides, but to make it sufficiently hard and impenetrable to keep it from the attacks of other animals, and, moreover, to afford it shelter against the inclemency of the season; nevertheless, this prodigy is every day to be witnessed on a small scale in the case of these humble maggots, which convert their skins into a compact and well-constructed abode. Other larvæ, such as caterpillars, as we have seen, cast off their skins completely, several times during the course of their existence, by splitting them down the back, and crawling out of their old coverings; but the maggots, of which we are now speaking, seem to have a much more puzzling task assigned to them; for not only do they separate themselves from their old skins, but they still retain it as a sort of cocoon, after remodelling it into a determinate figure adapted to their shape.

The maggot is much more attenuated towards its anterior than towards its posterior extremity; but when it chooses it can contract itself into an oval form, by drawing its head and the first rings of its body within the succeeding ones; and this it never fails to do, as soon as it has buried itself, in order to assume the exact shape of the future chrysalis, so that, when dug out of the ground eight or ten hours after it has buried itself, although still a maggot, it might be thought that its metamorphosis was completed, were it not that its colour is still that of the larva, and not of the pupa. In this condition, however, it soon betrays its real character, by protruding its head and elongating its body, so as to resume the appearance which it had whilst in the meat, and by crawling about as before. On escaping into the ground again, it immediately resumes its former contracted shape.

When the maggot has at last permanently assumed this figure, it is still as white as it was at first, the only difference between that which is really metamorphosed, and that which is about to become so, being, that the former cannot move even when handled, while the latter never fails to show its head. Moreover, the transition from the larva to the pupa condition is very speedily accomplished, so that a maggot, when first taken in the hand, may be really such as indicated by its movements, which, after the lapse of five or six minutes, shall contract itself for the last time, and become, permanently, a chrysalis. No sooner is this change accomplished than the skin, which was before white, begins to change its colour, a few minutes being sufficient to give it a decided red tinge, which, in the course of a few hours more, becomes converted to a deep chestnut colour. As soon as the skin is thus converted into a cocoon, even while it is still white, it is very tough and solid, resembling leather both in its thickness and density, and it would seem that in order to insure this needful thickness, Nature had economised the skin in these maggots by adopting a very different proceeding in respect to them from what is witnessed in the generality of the insect races. Most other grubs change their skins many times during their larva-growth, but in the case of these flies no such change is permitted, so that the chrysalis-envelope may be supposed to be equivalent in thickness to all the four or five skins which caterpillars successively throw off: moreover, its strength is considerably augmented from the circumstance that, after the completion of the metamorphosis, the chrysalis is considerably smaller than the original maggot, so that what it loses by contraction in its superficial dimensions, doubtless adds considerably to its thickness.

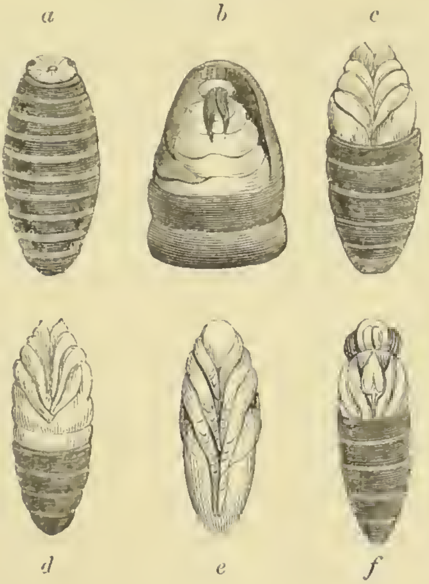
If the chrysalis-case of the pupa of the flesh-fly be carefully examined, it is found to consist of a series of rings, which are more distinctly recognisable than they were in the larva form, but there is not the slightest trace of any of those limbs which must afterwards be possessed by the future fly; it therefore becomes extremely interesting to inquire what is the condition of the contained insect after it has thus made a coffin of its own skin, and how it progressively assumes the proportions and attributes of the winged fly. If one of these cases be opened, even after the lapse of twenty-four hours, not the least indication of the organs of a fly can be detected; indeed, the whole of its interior seems to be filled up with a kind of creamy mass, having the general form of an egg, but which, even when hardened by being boiled in water, has no resemblance to the future insect. Nevertheless, it is strangely different from the original maggot. The latter was thick behind, and tapered gradually towards the head, where was situated the mouth armed with two horny hooks, but now both ends of its body are nearly of the same dimensions; it has also lost all power of motion, and, moreover, with its skin it has cast off the stigmata through which it formerly breathed, or at least has lost all connection with them, except through the intervention of the old tracheæ, which themselves have been partially discarded. The hooks and scaly lancet, which armed the mouth of the larva, are found attached to the cast-off skin, their roots appearing to have been drawn out from a deep cavity visible in the anterior end of the egg-like mass.

This rude condition, in which the insect seems neither to have life nor to be capable of animation, is very transitory, for if the chrysalis-case is not opened until four or five days after the metamorphosis into the pupa condition has been effected, it will be found to contain a nympha, presenting all the organs of the fly in a very forward state of development (fig. 67). The legs and wings are distinctly visible, although contained in separate but very delicate sheaths. The head is large and well formed, and the compound eyes, and all the parts of the proboscis are easily examined.

The proceedings whereby this wonderful change is accomplished are, moreover, different from what is witnessed in other insects, which generally have only to throw off another skin in order to display parts already formed beneath it, as the caterpillars of Lepidoptera are immediately converted into chrysalises ; but it is only gradually that the limbs of these flies make their appearance ; and as nothing is more easy than to procure abundance of chrysalises such as we are now describing, and watch them from day to day, the reader may easily trace their development, more especially if the precaution be taken to immerse them in hot water so as to harden the parts within, previously to examining them. It will then be found that, at the end of two or three days, short legs become visible, apparently sprouting from the anterior portion of the egg-shaped mass (fig. 67 *c*). On the day following, these legs are considerably lengthened (*d*), and the wings become visible (*e*). Another day reveals the end of the proboscis (*f*). Subsequently, the proboscis appears complete, and the head becomes distinguishable; and, lastly, all the parts are completed preparatory to the escape of the fully formed insect.

From what is thus revealed by a daily inspection of the progress of the egg-shaped mass towards the condition of a perfect insect, it would seem, at first sight, that the head and wanting members were produced in succession, and grew hour by hour until they attained their full dimensions. But this development of so many new organs, while the body seemed not to grow at all, but always completely filled the chrysalis-case, was by no means easy to explain, and Reaumur, in investigating this part of the subject, at last found out that the production of these new parts was only apparent, and that their successive appearance was due to a very remarkable arrangement.

Fig. 67.



We have already noticed a cavity, situated at the anterior extremity of the egg-shaped mass contained in the chrysalis-case (fig. 67 *a*), in which the roots of the dental apparatus of the maggot had been originally implanted. Upon each side of this cavity, Reaumur remarked that there were invariably situated two little horny eminences, which he thought might be stigmata, and soon found that he was right in his conjecture; these stigmata being, in fact, those which would afterwards belong to the thorax of the fly. Such being the case, it followed that the head of the fly, or that part which would become converted into the head, was actually situated nearer to the hind part of the pupa than the rings of the thorax. In a word, he began to suspect that all those parts which seemed to grow day by day were, in reality, already formed, but placed at the bottom of the cavity above mentioned, from which they gradually emerged as their development was slowly accomplished.

" In order to picture to himself what I now wish to make intelligible," says Reaumur, " let the reader imagine a kind of human monster, with its head, neck, shoulders and arms, all pushed so deeply into the cavity of its chest that not only no portion of them shall be visible, but that there shall seem to be a deep cavity at the end of the trunk. Now, positively, what in the case supposed would be fantastic and misshapen, is the natural condition of the insect at this period of its metamorphosis. Let us now imagine it possible to restore our supposed monster to the human shape by drawing out the hands and arms, which would take their natural position—the head would then show itself, and afterwards the neck, which being fully stretched out, everything would take its proper shape."

To prove incontestably that what has been supposed above is precisely what happens in the insect, Reaumur took a pupa, which still exhibited the appearance of an elongated ball, without any limbs as yet visible but the ends of the legs, and those very dimly perceptible, without the slightest appearance to indicate the existence of a head—an insect, in fact, exactly comparable to our supposititious monster, protruding only its hands and a portion of its arms. He then gently pressed the pupa, so that the pressure should act from behind towards the fore-part, when, lo! the cavity in front of its body immediately began to turn itself inside out, and parts soon became visible which before had been totally concealed—the head ready furnished with its antennæ and proboscis, as well as with eyes distinctly formed. The legs, moreover, increased in length, and not only did parts appear which were previously undiscoverable, but those parts which had been indistinctly seen before, both legs and wings, swelled out into high relief, owing to the fluid which was forced into them. In fact, an insect seemed to be manufactured on the spot, and a transformation accomplished in a few seconds, which, in the ordinary course of nature, would have occupied several days.

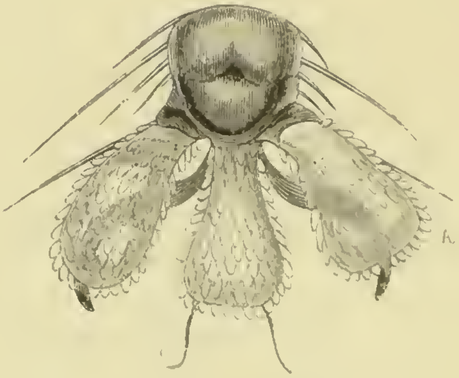
The fly having attained its mature condition, it remains next to be seen in what manner it is enabled to escape from the pupa-case, in which it has undergone such extraordinary changes of form. In order to facilitate this part of the process, a very elegant arrangement has been adopted, which cannot fail to excite our admiration. That end of the horny envelope which corresponds to the head of the included fly, although it seems to be as thick and as solid as the rest, is, in reality, converted into a sort of door composed of two lateral halves, easily separable from each other, and likewise capable of being detached from the rest of the pupa-case by a very slight effort, thus leaving an ample opening through which the fly may pass; and, indeed, the naturalist may easily avail himself of this natural lid, which drops off on the application of a very slight force, to enable him to examine the progress of the included insect towards maturity, without risk of injuring its as yet delicate members. The manner in which the perfect fly escapes may easily be watched by any one who has the curiosity to witness this part of the process, which is, indeed, by no means the least interesting.

The question is, by what means does the fly, closely packed as it is in its pupa-case, and apparently as incapable of motion as an Egyptian-mummy, open the door provided by Nature for its escape, and, subsequently, extricate its limbs from their enthralment?

The head of the fly is solid, and completely encased in scaly and inexpansible pieces, but in order to raise its coffin-lid, it is able, prior to its exclusion, to contract and dilate this part of its structure by alternate movements of a very wonderful character, and, moreover, to protrude from the anterior and upper portion of its head, a very remarkable apparatus, the use of which cannot be misunderstood. This consists of a great white bladder (fig. 67 *f*), which can be distended at the pleasure of the insect, until its size equals, or even surpasses, that of the entire head, and be again drawn in until it totally disappears, or it can be moulded into all shapes and sizes which may be required, in order completely to push off and get rid of the covercle, which closes the extremity of the pupa-case. The only means at the disposal of the nascent fly for thus distending this remarkable bladder, which will never become visible again during its whole life, and dilating its whole head, the parts of which are afterwards fixed and immovable, would seem to be the forcible injection of the air, which permeates its whole body, and which, as we shall immediately see, performs a very important part in effecting the expansion of its limbs. As soon as the fly has forced off the lid of its pupa-case, it pushes its head through the opening; afterwards, its thorax is liberated, and then its legs are drawn out of their investments. When the front pair of legs is disengaged, indeed, all the difficult part of the work is surmounted, nothing remaining to be done but to extricate the other limbs and the rest of the body, leaving behind the thin white skin in which they had been enveloped, and the discarded tracheæ which remain attached thereunto.

The aspect of the new-born fly is, however, still very different from that which it will soon assume. The *blue*-bottle fly is as yet of a light grey colour, and that only because the hairs upon it are black, whilst its whole body retains a whitish appearance. But, in the course of two or three hours all is changed—the brilliant blue tints are fully established, the head, thorax, abdominal rings, and legs, have become hard and firm, the wings at first crumpled and inconspicuous, acquire their full expansion and stiffness, and the fly is ready to use them for the purposes of flight.

Fig. 68.



FOOT OF A FLY.

A most beautiful example of the facility with which the most generally established laws may be laid aside in order to meet special contingencies, is observable in the race of flesh-flies, which, from their pre-eminent carnivorous propensities, have acquired the name of *Sarcophaga* (flesh-eaters), and whose duties are especially confined to the destruction of carrion. In the production of these active cleansers of the earth, it has already been stated that the usual proceeding of laying eggs and waiting for a few days, or even hours, for the production of the devouring larva, would be too slow to meet the necessity of the case, and, accordingly, we find that instead of depositing eggs, the common *Sarcophaga carnaria*, and other species of flesh-flies, give birth to living young ones—maggots already active and hungry, eager to begin the work assigned to them, and able, from their multitudes and prodigious voracity, at once to become efficient labourers for the general good.

The manner in which so important a modification of the usual plan is effected is, moreover, by no means so simple as it may at first sight appear to be, for we might suppose that by merely delaying the time of oviposition, the eggs would be extruded, ready hatched, exactly as the viper, among reptiles, can be made to produce eggs or living young ones, almost at pleasure, by accelerating or delaying the period at which they are born; but the case is very different with the flies in question, in the organization of which the anatomist immediately perceives a remarkable resemblance to that of the Lamprey and other highly-prolific fishes. On opening the abdomen of one of these flies when nearly ready to lay eggs, its cavity is found to be almost entirely filled with a broad viscus, apparently entirely composed of eggs packed closely together so as to form a flattened band, folded up in a spiral form like the spring of a watch* and which, when unrolled, is found to be no less than two inches or two inches and a-half long, although the whole length of the fly is not greater than the third of an inch. Reaumur was curious to know how many eggs (for such they seemed to be) were contained in this wonderful band, and found them, at a moderate calculation, to amount to upwards of twenty thousand! A closer inspection, however, shows that, instead of being eggs, these are all living larvæ, each wrapped up in a separate covering of inexpressible delicacy, and that instead of being born in the usual manner, all these grubs break loose, as they become mature, into the abdomen of the parent-fly, where they are carried about and nourished until an opportunity occurs of depositing them upon substances suitable for their nourishment! It would even seem that different races have a special predilection for particular kinds of carrion — the different species of the genus *Cynomyia*, at least, are only to be met with on the dead bodies of dogs, and perhaps others may be found to be equally fastidious in their tastes.

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* Reaumur, vol. iv. pl. 29, fig. 8.

The *Tachinidæ*, another family of the flesh-eating flies, pass the earlier stages of their existence in the bodies of the larvæ and pupæ of other insects, or even the mature insects themselves, where they live a parasite life, much after the manner of the *Ichneumonidæ*, whence they have received the name of *Muscæ larvarum*. Into these the young maggots penetrate as soon as they are born, and pass a life of apparent luxury, revelling among the fat which is so abundantly stored up in the caterpillars and chrysalises that they frequent; and instances are on record, of the pupæ of these *Tachinidæ*, which have lived in the bodies of other insects, being themselves filled with numerous parasitic larvæ of flies of still smaller dimensions, but of kindred habits.

The *Œstridæ*, instead of depositing their progeny upon the offal, or carcases of dead animals, deposit them in living quadrupeds, and make the strongest of our cattle the involuntary, and not unfrequently the unwilling, nurses of their offspring; nay, it would seem that each species selects a particular kind as the victim of its persecutions and the nourishment of its brood. It is, however, exclusively to herbivorous quadrupeds that they entrust the precious deposit,—the horse and the ass, as well as horned ruminants, such as the ox, the reindeer, stag, antelope, camel, and sheep, being the principal objects of their attack: others, however, are not spared; nor can the fleet course of the hare, or the giant bulk of the rhinoceros, command exemption from their unwelcome visits; nay, even man himself is sometimes unable to defend himself against their importunity.

The *Œstrus bovis*, or gad-fly, when about to lay, repairs to the pastures frequented by oxen, and, singling out the fattest, sleekest, and most healthy of the herd, by means of an ovipositor, specially constructed for the purpose, introduces an egg beneath the skin of its back or shoulders. Having accomplished this, she flies to another place, and repeats the operation: so that sometimes a poor heifer is made the unconscious depository of twenty or thirty of these valuable bequests. The gad-fly having accomplished this important task, takes her departure, apparently well satisfied that in such keeping her young ones will be in no danger of starvation.

Thus warmly lodged, the eggs are soon hatched; and from the irritation produced, an abscess is speedily formed around each, in which the young maggot is destined to live and nourish itself, by imbibing the purulent fluids in which it is constantly immersed.

We have already seen various admirable contrivances, whereby larvæ of various kinds have been enabled to respire under circumstances where to obtain a supply of atmospheric air seemed a matter of great difficulty; but in no case, perhaps, have the difficulties been greater than in that of grubs so singularly placed as those we are now considering; nevertheless, their respiration has been efficiently provided for, and that by a very simple mechanism. In the middle of every one of the artificial boils* formed by the swellings, which indicate externally the position of these abscesses, a hole is left through which the egg was originally introduced, and as the abscess enlarges, this hole increases in size. The aperture is, however, constantly filled up by a broad flat plate, which closes it like a cork, and which examination soon discovers to be the hinder extremity of the grub, converted into a breathing apparatus, admirably constructed for the purpose, which we will now proceed to describe.

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* These lumps are called by graziers wormils, or worbles, and are rather looked upon as indications of health, than otherwise.

The hinder part of the maggot consists of a flat circular disc, so formed as accurately to fit the orifice of the swelling, and is generally on a level with the margin of the aperture.* The disc is divided into two unequal halves by a line passing across it above the centre. In the larger division, are two prominent horny plates, of a brown colour and somewhat crescentic shape, the concavities of the crescents being turned towards each other. In the centre of each of these crescents, and bounded by their horny edges, is a large spiracle, which the horny frame keeps constantly open and permeable. In the smaller division of the circle there are, moreover, eight other small apertures, the margins of which are likewise apparently corneous, arranged in a straight line like the holes of a flute, which are all of them so many passages whereby air gains free admission to the tracheæ situated within the body: it is therefore easy to understand how, as long as this disc is exposed to the air, respiration is freely carried on, although all the rest of the larva be immersed in the animal fluids upon which it feeds.

After having attained its full growth, the larva proceeds to leave the nidus in which it has been so long lodged and boarded; in order to effect which, it gently and gradually dilates the external orifice of the tumour by the constant pressure of its body, until at last it has made a passage sufficiently large for its escape. It then gradually works its way backwards out of its prison, and, falling to the ground, proceeds to make preparation for its final change.

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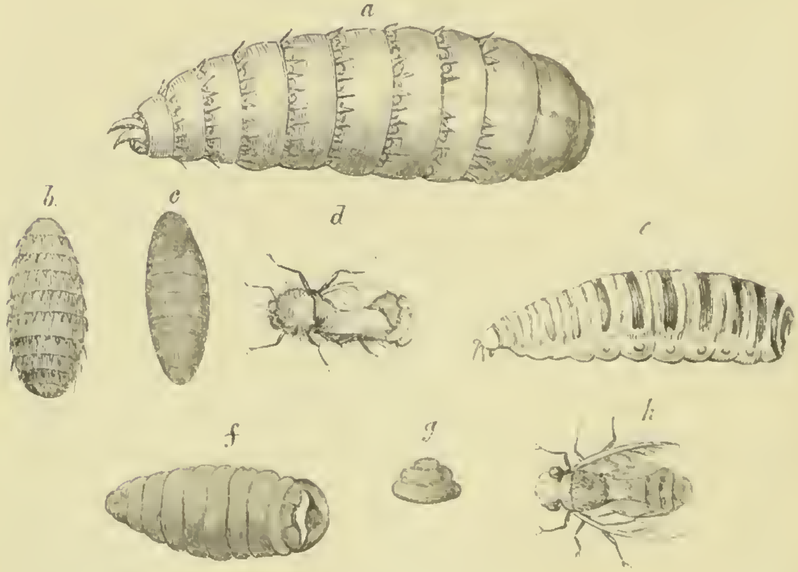
* Reaumur, vol. iv. pl. 37, fig. 3.

Arrived upon the ground, it betakes itself to the nearest shelter, and hides itself among the grass, or under some neighbouring stone, where, in about twenty-four hours, it becomes converted into a pupa, encased in a hard, black, and leather-like covering, formed of its old skin, and, in the course of a few weeks, makes its appearance as a two-winged fly.

Fig. 69.



Another tribe of the *Œstridæ*, the bot-flies, (fig. 69), are educated during their larva condition in a situation even still more remarkable, their nursery being the *interior of the stomach* of the animal that yields them support. The manner of their introduction to this strange locality furnishes another striking illustration of the adaptation of instinct to the most extraordinary circumstances. The parent of these grubs, usually known by the name of *Bots*, anxious to obtain for her eggs admission into the warm and well-provisioned regions where her future progeny are to be nurtured, is obliged to have recourse to stratagem, in order to accomplish her apparently impracticable design. For this purpose she proceeds to glue her eggs to the hair of the horse's fore-legs, or to some other part of the body which he is in the habit of licking; and having effected this, she flies away, leaving her eggs to take their chance of being taken up by the horse's tongue, and thus conveyed into his stomach, where, being kept at a very exalted temperature, they are speedily hatched. The larvæ have their bodies covered with rows of strong hooks, which encircle the margin of every segment, whereby they securely fix themselves to the walls of the cavity that contains them, until they are sufficiently mature to be discharged from their singular abode. They then hide themselves in the earth; and their skin becoming converted into the shell of the pupa, the rest of their development is accomplished, as in the case of the ordinary flesh-flies.

It is not only in the stomachs of horses, however, that flies of this family find materials for the support of their progeny, some species depositing their ova in situations even yet more curious and unexpected. Thus, for example, in many ruminant quadrupeds, such as the sheep, the goat, and the different tribes of deer, the walls of the skull and the bones of the forehead and face are hollowed out into capacious cavities that communicate with the nose, into which they pour an abundance of glairy fluid; and even this mucous secretion is made available for the nourishment of certain œstridous larvæ. The *Œstrus ovis* is accordingly instructed to deposit her eggs in the inside of a sheep's nose; and the ova becoming hatched in this situation, the young larvæ to which they give birth soon insinuate themselves into such cavities as are fitted for their reception, where their growth is rapidly accomplished; after which, they are content to crawl out of their snug retreats, and, dropping to the earth, bury themselves there until their metamorphosis, which in every respect resembles that of the other *Œstridæ*, is accomplished; when they, like their progenitors, set out in search of sheep's noses, wherein to secure a residence for their offspring.

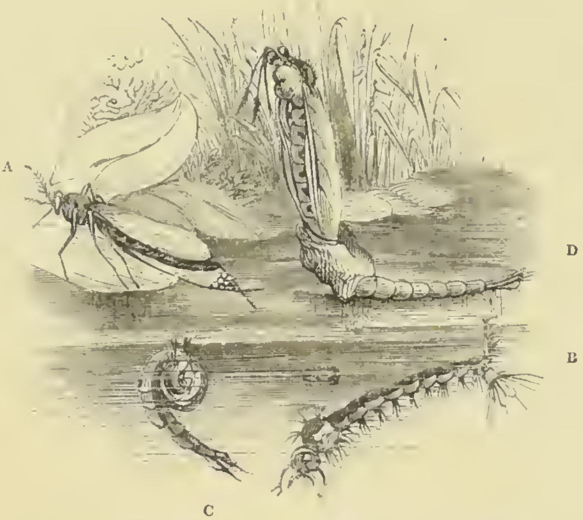
Gnats (*Culicidæ*).—The eggs of these insects are deposited in water, and in their shape exactly resemble so many minute ninepins or skittles, the upper end of each being pointed, while the lower is flat and furnished with a little horny lid. It would seem, moreover, that these eggs must be kept at the top of the water, in order that the included embryo should have a free supply of atmospheric air; for it has been observed that if the eggs are permitted to sink, they speedily perish; and seeing that individually they possess but little buoyancy, it is not easy to see how they may be supported at the surface. For this end, a very beautiful contrivance has been adopted. The little gnat joins her eggs together with consummate art, and with them constructs a boat in every way adapted to meet the necessities of the case, which, as the reader will soon perceive, involve many nice considerations. In order to construct her little skiff of eggs, the parent gnat alights upon the surface of the pond, where they are to be deposited, and fixes herself firmly, by means of her four front legs, upon some floating object able to sustain her weight. She then stretches out her hind legs backwards, crossing them into the shape of the letter x; thus readily making the framework, or stocks, as the shipwright would be tempted to call it, upon which the vessel is to be built (fig. 70), and which prevents the tiny fabric from sinking until its construction is completed. At the commencement of the operation, the legs are crossed close to the hinder part of the gnat, ready to receive the first laid egg in the angle formed between them, and retain it in that position while the succeeding eggs are glued to it, row after row, in a gradually increasing series, until the prow of the boat is formed. The legs are then uncrossed and stretched out like two long beams, marking the boundaries of the central part of the vessel (fig. 70, A); and this being completed, the other extremity is tapered off by progressively diminishing the number of eggs in each row, until the boat is finished and the gnat commits it to the waters. Not the least admirable part of the process, is the rapidity with which one of these specimens of insect ship-building is completed. Each egg, immediately that it is produced, is accurately placed in its proper position, where it is at once fixed by means of a kind of glue or varnish, with which it is besmeared; and as fifteen or twenty eggs are thus deposited in the course of a minute, the work proceeds apace, a quarter of an hour or twenty minutes being quite sufficient for its accomplishment.

But another and more important consideration must by no means be left unnoticed. On examining one of these boats, it is immediately perceived that the eggs composing it are so arranged that their lids, through which the larvæ have to escape are all turned downwards towards the water, in order that when the larvæ issue from them they may immediately find themselves in their proper element. It is therefore obvious, that if by any accident one of these frail barques should be capsized the lids would be raised into the air, and the inducted young inevitably perish.

One of the great desiderata of modern times has been a life-boat constructed upon such principles that it could not be permanently upset, and at last mathematical science has invented, or adopted, a pattern which possesses this important requisite; but even here, as in so many other instances, the results of human ingenuity have been long since anticipated, every raft of gnat's eggs being, in fact, a life-boat of the most perfect kind, for, let it be upset in any possible manner, it will immediately right itself and resume its proper position on the water.

If one of these little canoes be put to swim upon the surface of a glass of water, in the course of a couple of days the young larvæ will be found to have made their escape from the egg-shells, and

Fig. 70.



may be seen swimming about in great numbers, from two hundred and fifty to three hundred, or even three hundred and fifty, issuing from each boat, which, thus emptied of its cargo, swims about on the surface of the water until it perishes from decay.

The larvæ (fig. 70, B) present a very remarkable appearance, and during the summer may easily be procured from almost any stagnant pool. They are quite destitute of legs, their place being occupied by tufts of hair attached to the different segments, by the aid of which, and of rapid jerkings of their tails, they are able to leap about in a very extraordinary manner, and with more activity than from their appearance we should give them credit for.

Their food appears to consist entirely of imperceptible animalcules or vegetable particles, caught in currents produced by the rapid movements of several tufts of hair placed in the immediate neighbourhood of the mouth, which otherwise is totally unprovided with jaws adapted to mastication. The usual position of these larvæ is at the top of the water, where they remain, as it were, suspended by their tails, breathing the air of the atmosphere through a respiratory organ of a very curious construction. This consists of a long tube (fig. 70, B), inserted near the hinder part of their body, the free extremity of which is kept above the surface of the water by a curious set of paddles attached to the last segment, and thus air is freely admitted into two long tracheæ, continued from the breathing tube, whereby it is diffused through every part of the system.

After having several times changed their skin, which is cast off in a very entire condition, these larvæ proceed to enter the pupa state, and, casting off their last larva-investment, present themselves to the astonished spectator under such a different aspect from that which they previously presented, that he is not easily convinced of the identity of beings so dissimilar in every part of their economy. The pupa (fig. 70, C) in fact presents a very grotesque appearance, and although still able to move about with the assistance of its tail, has lost all power of eating, its mouth being concealed beneath its new envelope. But the most extraordinary part of the change is the complete removal of the respiratory apparatus of the larva from the vicinity of the tail, and the substitution of two breathing-tubes, which are now found implanted into the most prominent part of the back, in consequence of which the position of the animal in the water is completely altered, as it is now compelled to swim in the attitude represented in the figure. The necessity for this wonderful transposition of the breathing organs, preparatory to the commencement of the final metamorphosis of the gnat, will become apparent to every one who reflects for a moment upon the circumstances connected with the transition of these little insects from the aquatic form, under which they live as larvæ, to their winged condition.* The larva, it will be remembered, is quite destitute of legs wherewith to climb out of the water preparatory to assuming its aerial character; and moreover, being suspended, as it were, by the tail with its head downwards in the water, it could not by any possibility throw off its outer covering while thus situated, without wetting its newly-formed wings, a calamity which would necessarily prove fatal to its existence; but no sooner is the position of the breathing pipes changed than the rest of the process becomes extremely simple; the back of the pupa is slightly projected above the surface of the water, the pupa-case becomes fissured along the exposed part, and, as the split extends, it expands into a little boat, in which the nascent gnat sails about until every preparation for its entrance on a new sphere of life is completed. The last scene of this interesting spectacle is easily to be witnessed by any one whose curiosity may prompt him to enjoy it, for it is only necessary to procure a large vessel, well stocked with larvæ and pupæ, procured from any neighbouring ditch, in order to find some of them undergoing their final change, at any hour of the day, but more especially about noon.

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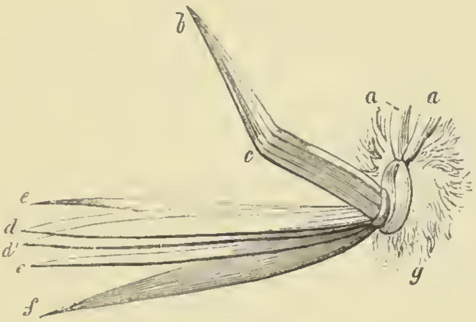
* Réaumur, vol. iv. pl. 3 and 44.

The pupa about to assume its winged condition remains, as before, quiet at the top of the jar, but, instead of having its tail folded beneath its body, it is now stretched straight out on a level with the surface of the water, above which the thorax, with its breathing tubes, slightly projects. Hardly has it remained an instant in this position when, by dilating the anterior portions of its body, it causes the skin of the pupa to split along the back, just in the middle, between the two breathing tubes, and the rent quickly increasing in length, displays the greenish-coloured body of the gnat placed beneath. As soon as the fissure is thus completed—and its completion is the affair of a few seconds—the gnat proceeds to extricate its head, which it raises above the margin of the opening. And now begins a very critical period of its life, during which it is exposed to most imminent peril. A few minutes previously it had lived in the water, and would have soon perished had it been placed on dry land; now it has nothing to fear so much as the water, for should it happen to be upset, or even wetted in the slightest degree, it must inevitably perish. Its proceedings under circumstances of so much delicacy are truly admirable. As soon as the head and thorax of the issuing gnat are through the opening they are lifted into the air as far as possible, and its tail being at the same time advanced forward, the pupa-skin is left empty both behind and before. In this manner the pupa-case becomes converted into a sort of boat (fig. 70, D), into which the water does not penetrate. The body of the gnat itself forms the mast to the little barque. We frequently see large boats that have to pass under bridges, with masts so constructed that they can be laid down flat, or gradually hoisted up until they stand perpendicular to the deck, and exactly in the same manner does the insect raise itself erect until it seems to stand on nothing but the end of its tail. It is indeed difficult to imagine how the little gnat manages to put itself into this remarkable attitude, which, however, is absolutely necessary for its welfare, or how it can maintain so strange a position, seeing that neither its legs nor its wings can assist it in any degree, the former being kept stretched out and laid flat upon its body, while the latter are as yet quite soft and crumpled: the rings of its body must be the only agents employed. The observer, who sees how heavily loaded the little canoe appears, and how near its edges are to the surface of the water, forgets for the moment that the gnat is an insect that at any other time he would fain kill; he feels a positive interest in its fate whilst its life appears thus trembling in the balance, and sees with pleasure how the skiff sails gently along, wafted by the currents of air. Should the wind, however, rise but a very little, the utmost anxiety is felt lest the frail barque should be upset, an accident by no means uncommon if the weather becomes at all rough before the completion of the process. When this catastrophe occurs, and the poor gnat once touches the water, it is all over with it; and sometimes the water may be seen covered with the bodies of multitudes that have perished in this manner. More commonly, however, the operation is safely completed; it is soon over, and the period of danger does not last longer than a minute.

The gnat, thus standing up perpendicularly in its boat, first draws its two fore-legs out of the delicate sheaths that encase them, and subsequently extricates the next pair in a similar manner. Having accomplished this, it is able to relieve itself from its former fatiguing position. It now bends forwards, and places its four front legs upon the surface of the water, which is found to be a sufficiently firm and solid support for such a tiny being. When thus much has been accomplished the danger is over, the wings speedily unfold themselves and become dry, and the gnat, now fully prepared to make use of them, soon flies away to join his comrades in the air.

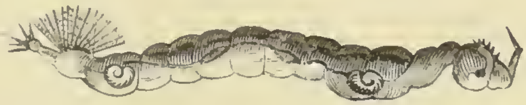
Gnats, as might easily be supposed from the prodigious swarms in which they frequent marshy places, are exceedingly prolific, and, moreover, many generations of them succeed each other in the course of a year, the duration of each not being longer than three weeks or a month, in which time all their metamorphoses are gone through, and they are ready to give birth to new swarms. But allowing that the first generation only made its appearance in May, and the last towards the end of October, there would be at least six or seven produced in the course of the year; and seeing that each female will lay from two hundred and fifty to three hundred and fifty eggs, the reader will easily perceive how numerous may be the descendants of a single individual. Luckily, however, their enemies spare them not, and birds, more especially the swallows, devour immense numbers; and perhaps only leave us when their supply of food from this source begins to grow scarce.

Fig. 71.



The eggs of another kind of gnat (*Corethra*) swim upon the surface of the water, as in the preceding example, united together by a kind of viscous material, so as to form a little hollow dish, and the larvæ which

Fig. 72.

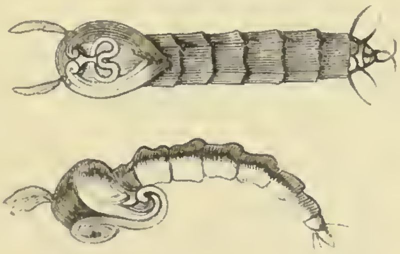


are produced from them present themselves under a very curious and anomalous aspect. The body (fig. 72) of one of these larvæ would seem to offer, in a rudimental condition, the parts into which it is divided in the perfect Insect, and a head, thorax and abdomen can easily be recognised; nevertheless it is perfectly destitute of legs, having a locomotive apparatus of an exceedingly novel and extraordinary character. This consists of a most beautiful fan-shaped fin, attached beneath the last segment of its body, and composed of about twenty straight diverging stems, each filament being barbed like a feather, so that the whole spreads out at the will of the animal, like a peacock's tail, and forms an oar, by the aid of which the little larva launches itself like a dart upon the prey it chooses to seize. Neither does this appear to be all the mechanism employed for locomotion. Through the transparent walls of the creature's body four little isolated bodies are visible (fig. 72), two situated in the back, and the other two in the vicinity of the tail. These organs are short, each of them being twisted into a spiral form, and present a silvery hue, very different from that of any other part of the animal. Seeing therefore that these larvæ, like the Pike among fishes, have the power of remaining for a long time together motionless, and, as it were, suspended in mid-water, and then suddenly launching themselves upon their victim, Lyonnet not unreasonably concludes that these four bodies are so many swimming-bladders filled with air, which being dilated or compressed at the will of the insect, will enable it to rise or sink or remain stationary at any elevation in the water wherein it dwells.

Another strange feature in the economy of the larva of the *Corethra* is the apparatus wherewith it seizes and devours such prey as it is able to devour. This consists of two arms or hooked appendages, each consisting of three pieces jointed together, which spring from the middle of the forehead and bend down in front of the mouth. With these the little tyrant lays hold of the hapless animal which it attacks with a spring like that of the tiger, and dragging it down, crushes it against two rows of sharp spikes, placed for that purpose at the lower part of the front of its head, on each side of its mouth (fig. 72), until it is sufficiently mangled and bruised to be easily swallowed by its destroyer.

In converting this footless aquatic larva into a little winged gnat the same difficulties present themselves as in the case of the *Culex*, and they have been overcome by a similar contrivance. We are not well acquainted with the nature of the breathing organs of the *Corethra* whilst in its larva condition, but, whatever that be, they are totally changed in the pupa represented in the figure, which now respires, like the gnat, through two pipes fixed in the upper part of its back (fig. 73), which in consequence must be brought to the surface of the water. This change occurs towards the middle of summer, when, after remaining for a few days under its new form, it proceeds to assume its winged condition ; the back

Fig. 73.

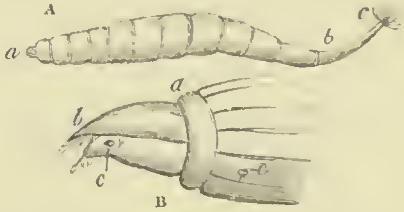


of the pupa rises more and more buoyantly above the surface of the pond, and as the pupa-case splits to give egress to the included insect, it becomes, as in the preceding instance, a boat, on which the little *Corethra* floats about for a few minutes until its wings are dry, and then enters upon its aerial existence.

(*Stratyomidæ.*) The larvæ of these flies are met with in ditches and stagnant marshes, and, at the right season of the year, may easily be procured and preserved, so as to enable the young entomologist to witness the remarkable phenomena connected with the singular form of metamorphosis through which they have to pass, seeing that sometimes numbers of them may be collected from the surface of the pond, where they float amongst the duckweed and other aquatic plants.

The shape of these larvæ (fig. 74, A) is very curious. The body is of an elongated form, without feet, and attenuated at each extremity, more especially the posterior; it is, moreover, slightly flattened, being broader from side to side than from above to below, and the rings towards the hinder extremity are considerably longer than the rest; but none of the segments are furnished with any external appendages, except a few scaly hooks of microscopic dimensions.

Fig. 74.



Their bodies are but little capable of contraction, seeing that the rings of which they consist can be drawn but very slightly one within the other, but they are generally found with the hinder segments bent at a considerable angle with the fore part; and, in fact, it is by thus suddenly and forcibly bending the tail backwards and forwards in opposite directions that the creature propels itself from place to place when it wishes to change its position.

The head (fig. 74, B) is small, and without jaws, but it is furnished with a set of very singular appendages (*a*, *b*, *c*), consisting of two horny hooks, four small points, and two palpi, dilated at the tips and clothed with stiff hairs. These the larva keeps constantly protruding and drawing back again, so as to produce currents in the water, which bring to its mouth animalcules and other small particles, that seem to constitute its only food.

Although inhabitants of the water, and entirely devoid of limbs, they, like all other aquatic larvæ, must breathe the atmospheric air; and this they succeed in doing by the aid of a very singular contrivance. The end of the tail is hollowed out into a little funnel-shaped cavity, the margins of which are surrounded by a circle of feather-like hairs, forming a beautiful float, whereby the end of the tail is kept buoyant above the surface of the pond, and the water effectually prevented from wetting the orifice of the funnel through which air is freely received into the body, and distributed by long tracheal tubes to every part of the animal. This circlet of hairs is, moreover, at the pleasure of the creature, convertible into a curious kind of hydrostatic apparatus; for, does it wish to sink into the water, it has nothing to do but to enclose a bubble of air among these radiating filaments, and thus convert them into a kind of reservoir to supply its wants until its return to the top of the pond.

When these larvæ assume the pupa state they undergo not the slightest change in their form or external appearance. Indeed, the metamorphosed animal so exactly retains its original shape that the accomplishment of the change is only manifest when it is taken out of the water and examined by the touch. We then find that instead of being soft, supple, and moveable, as it was before, it has become rigid, hard, and incapable of motion, and its body not unfrequently fixed in an angular or even zig-zag shape; the old skin of the larva has, in fact, become converted into the pupa case, in which the remaining stages of the metamorphosis are to be completed. If one of these pupa-cases be now opened (fig. 75), the pupa, or nymph, will be found to occupy but a very small portion of its larger extremity, having shrunk so much in its dimensions that its old investments can scarcely be conceived ever to have been adapted to it as a covering. At length,

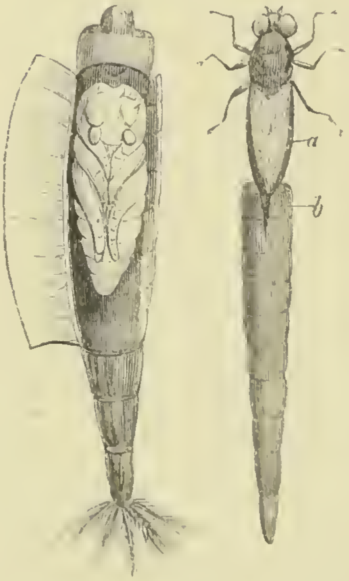


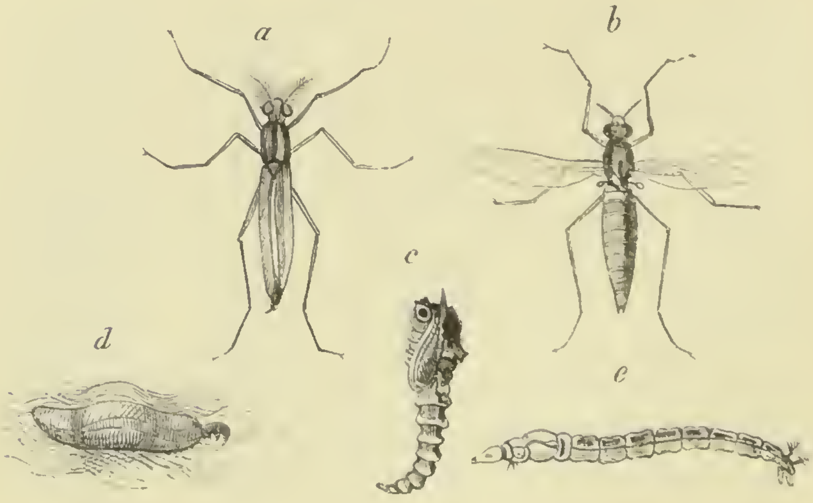
Fig. 75.

after the lapse of five or six days, the newly formed fly is sufficiently matured to begin to move its recently acquired limbs, and immediately commences its efforts to escape from the prison that encloses it, its exit being facilitated by a very beautiful prospective arrangement, the design of which is at once obvious. Those segments, which formerly constituted the head and the first ring of the pupa-case, are found to be converted into a sort of lid so constructed as to be weaker on the upper side than anywhere else, so that by the first exertions of the included fly this part of the lid splits like the skin of a caterpillar's back, when it is about to assume the chrysalis condition; having succeeded so far, the rest of the operation is comparatively easy, and the other attachments of the lid being gradually torn through, a door is soon opened, through which the fly can issue from its concealment (fig. 75).

But the greatest difficulty yet remains to be encountered—namely, the escape of the winged insect from the water of which it had been hitherto an inhabitant, for the generality of flies born from aquatic larvæ are as easily drowned as those produced from such as are terrestrial, and many of them perish at the instant of their birth, before their wings have had time to expand and dry; but in the case before us our little friends seem to have been specially favoured by Nature, the water becoming for them as solid a support as the earth is for us. For the fly has no sooner opened its lid than it advances straightforwards, walking as easily as upon firm ground, and placing its legs upon the water with the greatest confidence until they are all withdrawn from their coverings, and its body is entirely free. It then stands quietly upon the water supported upon its six legs, and never thinks of leaving it until all its parts are thoroughly dried and expanded. So completely, indeed, are these insects in safety from being wetted, that if upset they easily regain their legs, and seem to be not in the slightest degree embarrassed by the accident.

Larvæ of very remarkable construction, which likewise give birth to a kind of gnat (*Tanypus*), are met with in infinite numbers in every ditch, and as every one who uses a microscope cannot fail to have abundant opportunity of watching their singular proceedings, we are tempted to add Lyonnet's description of their habits to the illustrations already given. These larvæ (fig. 76, *c*) resemble minute worms, but upon close inspection divisions of the body corre-

Fig. 76.



sponding to head, thorax, and abdomen are easily distinguishable. The head is furnished with a pair of large eyes and powerful jaws, but in spite of its ferocious appearance when seen under a lens, its ordinary food would seem to be the fine green mossy substance that accumulates so abundantly in stagnant waters, wherein it is invariably found.

The first thing which strikes the observer on examining a larva of this description is the unique locomotive apparatus, by means of which it makes its way amongst surrounding substances; for instead of being furnished, like all other footed larvæ, with three or more pairs of feet, the little creature in question has only two pairs, and those of a most strange and peculiar organization. The front pair is attached beneath the first segment of the body (*e*), but the two legs composing it are so intimately joined together that they might easily be mistaken for a single limb, and, moreover, instead of terminating in simple claws as in other larvæ this compound foot ends in a large bunch of sharp recurved hooks. The posterior pair of legs is attached to the last segment of the body, but these are quite separate from each other, though, like the anterior ones, they are stiff and inflexible, both ending in tufts of hooklets, and only able to move backwards and forwards parallel to each other. This larva, in reality, therefore, possesses only three stiff legs, two behind and one in front, and its movements under such circumstances are highly grotesque and amusing. Instead of walking, or running, or crawling, as other insects do in their first state, this living tripod is compelled to adopt a sort of gallop, fixing first its hind and then its fore hooks alternately. In order to accomplish this it first stretches out its head and seizes hold of any object that may happen to be near with its jaws, and thus drawing forward its body, hooks on by means of its feet to the substance previously laid hold of by its teeth. It then lets go with its jaws, and once more stretching out its body, bites at something still further off into which it fixes its feet in the same manner. And by continually repeating the same proceeding, such is its activity that it gets on with astonishing rapidity, its undulating movements imitating by no means badly the gallop to which we have compared its pace.

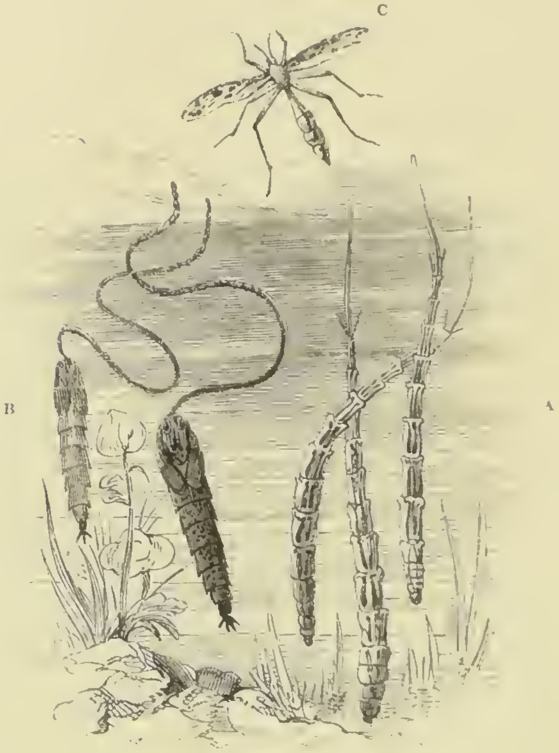
Each of these larvæ constructs for itself a little residence (fig. 76, *d*), composed of silk and delicate fibres of the mossy matter amongst which it lives. This abode, or sheath, is open at both ends and slightly barrel-shaped, but sufficiently thin to allow all the movements of the insect inside to be visible. It is, moreover, so soft and flexible as to accommodate itself to all the curvatures of the animal's body when it is in motion, a circumstance of no slight importance, seeing the vigour and vivacity of its motions, especially when dragging itself and its domicile through the moss that surrounds it, in doing which it twists both itself and its sheath into all sorts of contortions.

It not unfrequently happens that in burrowing through the moss the sheath sticks so fast that all the efforts of the little larva fail to extricate it; when this happens the young *Tanypus* soon makes up its mind what is to be done, and creeping out of its residence leaves it behind, and goes in search of materials wherewith to construct another; when out of its sheath, however, it changes its mode of progression, and instead of galloping as above described, it swims about with tolerable quickness by a succession of leaps effected by rapid zig-zag movements of its body.

About the latter end of March these larvæ assume their pupa investment, in which condition they resemble in every particular the pupæ of the *Culex* and *Corethra*, breathing in the same way through tubes inserted into the summit of the back, whereas in the larva state the respiratory tubes, two in number, were situated immediately above the tail (fig. 76, *e*), and in the course of a few days after this change has been effected, the perfect insect (fig. 76, *a*, *b*, male, female) comes forth, and, using its pupa-case as a raft to support it whilst its wings are drying, is soon able to leave the water where it was born, to pass the short remainder of its life a denizen of the atmosphere.

Other races of Dipterous insects proceed from larvæ, which, although aquatic, are totally different from any that we have yet encountered, and so curiously constructed that we cannot pass them over without at least a brief account of them. These likewise produce flies, allied to the *gnats* and *daddy-long-legs*, so that it is not easy to devise a reason why in their previous states they should present an organization so peculiar. The larvæ in question (figs. 77 and 78) are mostly found in reservoirs of water containing putrefying animal or vegetable matter, and accordingly it is in tanners' vats, and receptacles of that description, that they are generally met with.

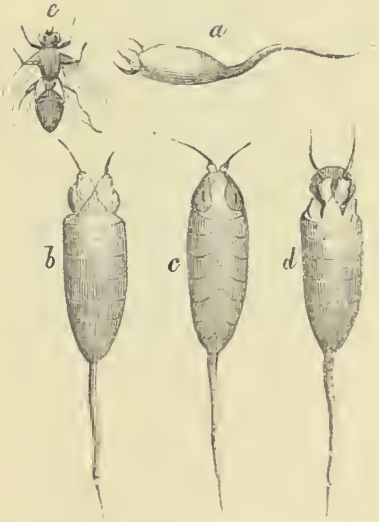
Fig. 77.



One of them, the larva of *Psychoptera paludosa*, copied from Lyonnet's figure, is represented in fig. 77, A, where the peculiarities of its structure are at once evident. The most striking feature in the appearance of these larvæ is the enormous tail appended to the hinder extremity of their bodies, whence they have been very generally distinguished by the name of *rat-tailed larvæ*, but the more modern appellation of *telescope-tailed larvæ* is far more applicable and expressive of the real nature of this singular appendage, which is, in fact, a cylindrical tube, or rather a succession of tubes one within the other, through which the creature breathes, and which it can elongate or shorten at pleasure, so as always to keep the orifice above the surface of the water, and thus secure a supply of atmospheric air for the purposes of respiration.

The whole apparatus is shown upon a very large scale in the figure, where the retractile character of the organ is at once apparent, and the convoluted air vessels which are derived from it, and pass into the body of the creature, become conspicuous. Arrived in the interior of the larva, these air-tubes are found to dilate in every segment (with the exception of the first three and last three) into large receptacles of air, which the creature has the power of distending or of compressing at pleasure, so that, besides serving for respiration, these organs constitute a hydrostatic apparatus similar to the swimming bladder of fishes, and by their assistance it sinks to the bottom of the water or rises to the top with

Fig. 78.



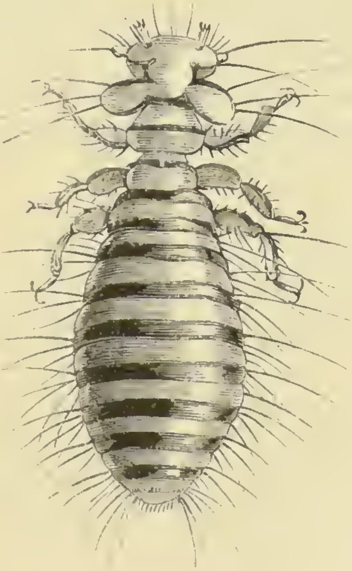
the utmost facility, and without any apparent effort.

About the end of the month of June these insects change from the larva to the pupa state, a change which is effected without leaving the water, and is completed in less than a fortnight. The approach of this event is indicated by the creature becoming more opaque, and of a whiter colour. Shortly afterwards it throws off its larva-skin, when, behold! the breathing-tube which before constituted the tail, is now transferred to the immediate vicinity of the head (fig. 77, B), where it is implanted into the back of the thorax.

After the lapse of another fortnight it escapes from the pupa-case and enters upon the winged state, under the form of the *Tipula* represented in the figure (fig. 77, C).

We must now prepare to encounter members of the insect world presenting themselves under less inviting forms, and exhibiting habits and appetites of a widely different character. These, although perhaps they do not offer so agreeable a subject for contemplation as others we have been describing, must not on that account be entirely passed over in silence, for so numerous are the varieties of their forms, and so extensive their distribution, that we must by no means allow their uncouth appearance, or strange mode of life, to prevent us from taking at least a passing glance at their countless legions. The races alluded to are all parasitic in their mode of life, infesting the skin, and lurking among the hair and feathers of quadrupeds and birds, where they seem to enjoy an abundant supply of materials adapted to their support. Their forms are infinitely varied, every species of hair-clad or feather-covered animal having apparently a race peculiarly appropriated to itself, nay, sometimes several different kinds are appointed to the same animal, all of which are quite distinct in form from those which infest any other creature, so that this despised group is positively richer in species than the great classes of quadrupeds and birds both put together. We pass over in silence the unmentionable example so elegantly apostrophised by the poet Burns, and from the thousands of varied shapes presented by these parasites, select only one as an illustration of the general appearance of those which infest the feathered tribes.

Fig. 79.



These, generally known by the name of *ticks*, assume innumerable grotesque shapes. That represented in the figure is met with on the eagle, among the feathers of which it may be supposed to lead a life of tolerable security. It is evident that to creatures thus circumstanced, dwelling as it were in an interminable forest of thickly serried bamboo-canes, wings would be of little use, and consequently the instruments of flight usually conferred upon the insect races are here totally denied. On the other hand, it must be apparent that under the peculiarities of the condition in which it is placed, feet of a very different construction to that of any we have yet seen will become requisite, and, accordingly, an apparatus has been provided at the termination of each leg (fig. 79), adapted to grasp most tenaciously the feather upon which the creature climbs, and thus secure such a hold as no other insect would be capable of. Making their way, therefore, in this manner through pathless regions which would be impassable to any other beings, these parasites devour the scurf and spoiled bits of feathers which they find in ample abundance, and perhaps in some way or other repay by their services the animal which affords them nourishment.

CHAPTER XVI.

ARACHNIDA.

Long confounded with the true Insects, even by scientific entomologists, and still, in ordinary conversation, regarded as members of that great group, are the Arachnidans, or spider tribes, a numerous and important class of animals, provided with articulated limbs, and presenting in their general appearance a sufficient resemblance to the creatures described in the last chapter, to render such an error excusable, at least in the uninitiated; but to the eye of the zoologist, wide is the distinction between a real insect and the beings we are about to consider, as will be manifest on a comparison of the leading features that characterize the two.

In the insect, properly so called, the body is naturally divided into three principal portions, the head, the thorax, and the abdomen, all of which, especially the two former, are so connected as to permit them to move freely on each other; but in the Arachnidan the head is firmly consolidated with the thoracic portion of the body, so that the two together constitute but one broad piece, named by entomological writers *cephalo-thorax.**

Insects are, in their perfect state, for the most part provided with wings; but among the Arachnidans these organs are invariably deficient; the former, likewise, undergo, during their preparatory states, a series of metamorphoses by which their form is completely changed, whilst the latter simply moult their skins, remaining throughout their lives in pretty nearly the same condition.

The organs of the senses are likewise very differently constructed in the two classes—the compound eyes of the insect, with their numerous facets, are replaced in the arachnidans by a small number of simple ocelli, variously disposed, and the antennæ, which in insects are evidently the seat of such delicate sensations, are here doubtfully represented by two jointed organs, terminated by a pair of forceps of variable structure, to which the names *chelicera* and *antenna-pincers* are applied by naturalists.

The arachnidans likewise differ from the insects in the structure of their mouths, in the arrangement of their respiratory and circulatory apparatus, in the number of their legs, and in many other important particulars which will necessarily present themselves to the reader's notice as we proceed.

It is, however, in the construction of the respiratory apparatus that the most marked differences exist between the true insects and the members of the class we are about to describe, as will be evident on examining the breathing apparatus of the scor-

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* Κεφαλὴ the head, ϑώραξ the chest.

pion (fig. 82), which, from its size, is well adapted to elucidate the singular mechanism whereby these creatures respire. On inspecting the inferior part of the abdomen of one of these formidable animals, four of the anterior segments are seen to be each of them furnished with a pair of large and very conspicuous breathing-holes, or *stigmata*, resembling in their shape and structure those of insects, each breathing-hole consisting of a narrow slit, surrounded by a prominent circle, more solid in its structure than the rest of the integument. Each of the stigmata, instead of communicating, as in the insect races, with tracheal tubes, leads directly into a kind of bag that forms the real breathing-apparatus, and is of very remarkable construction, being composed of numerous minute lamellæ arranged close together like the leaves of a book. These lamellæ are all hollow, forming so many membranous sacs, all opening into a common cavity, and their membranous margins are all round adherent to the horny circumference of the corresponding stigma or breathing orifice. This novel kind of breathing-apparatus has created some discussion among physiologists as to the name whereby it ought to be designated, some regarding it as analogous in structure to the respiratory organs of some fishes, calling the air-sacs *branchiæ*, while others preferred giving them the name of *lungs;* a dispute of very little importance, the truth being that most of these arachnidans prefer a humid or damp atmosphere, such as that of cellars and marshy places: modern zoologists have therefore done well in reconciling the contending opinions by calling them lung-gills, *pulmobranchiæ*, and the genera possessing such an organization, PULMOBRANCHIATA.

In the Spiders (*Araneæ*) the mode of respiration is essentially similar to that of the scorpions, but the number and position of the spiracles or stigmata is very variable; in some species four pairs have been counted upon the thorax, above the origin of the legs, four pairs on the upper part of the abdomen, and another pair upon its under surface, the last being apparently that most constantly met with, and, consequently, the most important.

In accordance with the changed arrangement of the respiratory apparatus, the whole structure of the circulatory system must necessarily undergo a complete remodelling. In the Tracheary Arachnidans, indeed, that have air-tubes dispersed throughout their bodies, the circulation of the blood is most probably carried on upon the same plan as in the class of insects, but as soon as pulmobranchiæ are given, blood-vessels must necessarily be provided to convey the blood to and from the breathing apparatus, and the following seems to be the arrangement adopted. The pulmonary arachnidans are provided with a dorsal vessel, arranged as in insects, along the middle line of the back, but which, instead of being provided with lateral valvular apertures to admit the blood from the whole body, is closed, except where it gives off or receives the vessels whereby the blood is distributed and returned. The course of the blood is as follows:—The contractions of the dorsal vessel propel the circulating fluid through numerous arterial trunks to all parts of the body, where it assumes a venous character, and is gradually collected into large irregular channels, or sinuses, that slowly convey it towards the pulmo-branchial organs, during its passage through which it is, by exposure to the air, again converted into arterial blood, and is then returned into the dorsal vessel through several large canals, thus completing the vascular circle.

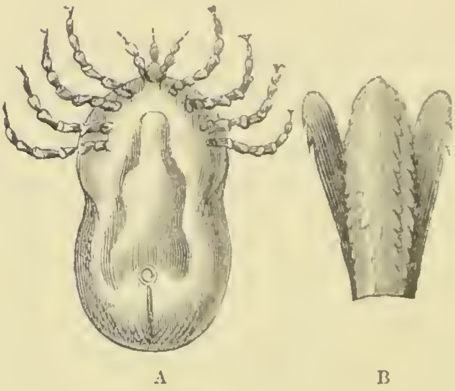
Let us now proceed to examine the principal groups under which the different races of arachnidans have been arranged by entomological writers.

The parasitic *Acari*, although generally confounded by the ignorant with the insect parasites, are easily distinguishable by many striking features, which may be thus concisely stated. In the first place they have eight legs, while no real insect has more than six; secondly, these legs are composed of a great number of joints, which cannot, as in the case of insects, be described as femur, tibia, and tarsus; and thirdly, instead of having remarkably large heads, they seem to have none at all, their head and thorax being so blended together as to form but one piece.

Many of these acari, well known by the name of ticks, infest the skin of different animals, and sometimes in considerable numbers. That which we have figured (*Ixodes ricinus*) will, however, serve to give the reader an idea of their general appearance; and although its aspect may not seem particularly prepossessing, it will soon be seen that no pains have been spared to adapt it to the circumstances under which it has to live.

These animals (fig. 80, A) are generally found attached to the poor creature upon which they live by means of a curiously constructed mouth, that is so firmly implanted into the skin, as to make it difficult to remove the tick without tearing off its head, except with the assistance of a knife, as will be easily understood when we describe the mouth wherewith it is furnished. No spear employed by the most savage nations was ever more fearfully barbed than this redoubtable apparatus; it consists of four lancet-like blades (fig. 80, B), each furnished with sharp teeth, so arranged, that while the instrument freely pierces the skin, to draw it back again by force is out of the question; and although the acarus can probably detach it by its own efforts, it is useless to employ foreign violence for that purpose. In the centre, between these barbed lancets, is the passage leading to the stomach of the parasite, which is thus

Fig. 80.



enabled to gorge itself at pleasure with the blood of its victim.

Quadrupeds and birds are not the only sufferers from the attacks of these disagreeable assailants. Snails, insects, both terrestrial and aquatic, and even caterpillars have likewise their appointed acaridian hangers-on, all specially constructed to exist under the particular circumstances required, and furnished with mouths modified in their character so as to meet the exigencies of the case.

It is, moreover, not upon animals only that the acari are found, many of them live upon vegetables of different kinds, whilst a whole family (*Hydrachnidæ*) inhabit the water, in which they swim with great agility by means of legs fringed with hair, and thus converted into oars.

The history of the water-mites, last mentioned, has been carefully studied by M. Dugès, from whose observations it appears that they, as well as other acari, undergo a kind of metamorphosis before they assume their adult form. The hydrachna, familiarly known on account of its brilliant scarlet or crimson colour, lays its eggs in the centre of the spongy stems of the pond-weed (*Potamogeton*), which it perforates with little holes by means of its beak, wherein to lodge them. The eggs thus laid are of a brownish colour, and so numerous, that they give the stem of the plant an opaque appearance where they have been deposited. The female finishes this task about the middle of May, after which she almost immediately dies. In about six weeks the young are hatched, and the stems of the pond-weed wherein they were lodged being by that time dead and half decomposed, they make their escape without difficulty.

The newly born water-mites are as yet in a larva condition, and instead of resembling their parent, have only six legs; they are, moreover, furnished with a most extraordinary proboscis, that from its enormous proportionate size might be easily mistaken for a head. In this condition the larva remains unattached, and swimming freely about in the water, until the end of summer, when it fixes itself to the body of some large water insect, generally a nepa, dyticus, or hydrophilus, to which it holds on so firmly that it is carried about with them, out of the water when they choose to fly, and is found on examination to have perforated their integuments with a narrow hole through which it sucks its food.

Having thus adopted a parasitic mode of life, the abdomen of the larva-mite begins to enlarge rapidly, whilst, on the contrary, the size of the proboscis, thorax, and extremities continues stationary, so that all its limbs seem transferred to the fore part of the body. Very often, whilst in this condition, some of its legs are found to be wanting, more especially if it has attached itself to an exposed part of an active insect, as, for example, to the leg of a dyticus, but on the next change of skin their number is again completed. The explanation of this remarkable phenomenon is, however, sufficiently simple. When the body, apparently of the larva, begins to grow so inordinately after the acarus has assumed a parasitic life, it has, in fact, entered upon its pupa state of existence, enclosed in the skin of the larva, and as its size enlarges, its legs are drawn backwards, concealed within the larva-skin, and are thus extricated from their original larva-cases, the latter of which may, therefore, be broken off by external violence, without the real legs receiving any injury. The pupa, although thus covered by its larva skin, continues nevertheless to nourish itself and to grow, being still fed by means of the sucker wherewith the larva perforated the integument of the water-beetle. These circumstances are by no means hypothetical, but may be proved by actual inspection, for through the transparent skin of the larva, the legs and palpi of the hydrachna were observed by M. Dugès partially retracted to a greater or less extent from their original cases, before the larva skin, by bursting, let forth the enclosed animal, which on escaping makes its appearance provided with eight legs, being two more than the original number. Another change of skin is, however, to be gone through before the creature can be considered as quite arrived at its adult condition, after which it is ready to lay its eggs, and then perish.

Innumerable are the species belonging to this extensive tribe, and widely are they spread throughout the world, although, owing to their minute size and uninviting appearance, they have as yet been very imperfectly studied. Many are erratic in their habits, and live under stones, or feed upon the leaves and bark of trees; numerous races assist in the great work of removing putrescent or decaying substances, of which the common cheese-mite is a familiar example;

some live a parasitic life attached to the exterior of the bodies of insects, more especially of such beetles as devour carrion or excrementitious matters, while others have the credit of producing various cutaneous diseases, as for example the *Itch-acarus* (*Sarcoptes scabiei*); many luxuriate in the ulcers and sores of different animals, and some even occupy the internal parts of living bodies, not even excepting those of human beings. Countless hosts, generally known by the name of *ticks*, lurk beneath the hair of dogs, horses, and cattle—nay, sometimes they become so prodigiously numerous as materially to interfere with the health of the creatures upon which they are found; the feathers of birds, too, afford them a convenient haunt, and, perhaps, it is not too much to say that there is no race of birds, from the soaring eagle to the humblest warbler of the forest, that has not got its peculiar parasites belonging to this despised and almost unknown division of the arachnidans; and when we reflect that no two species are identical in their form, or in the structure of their limbs, what an additional lesson do they teach us concerning the vastness of the animal creation, and the absurdity of criticising, through the medium of human prejudices, the limitless works of the Almighty.

Countless as are the devourers appointed to assist in the destruction of insects, none, perhaps, are more efficiently furnished for the purpose than the creatures we are next about to examine; insatiable in their voracity, unrelentingly ferocious, and gifted with extraordinary strength, cunning and patience.

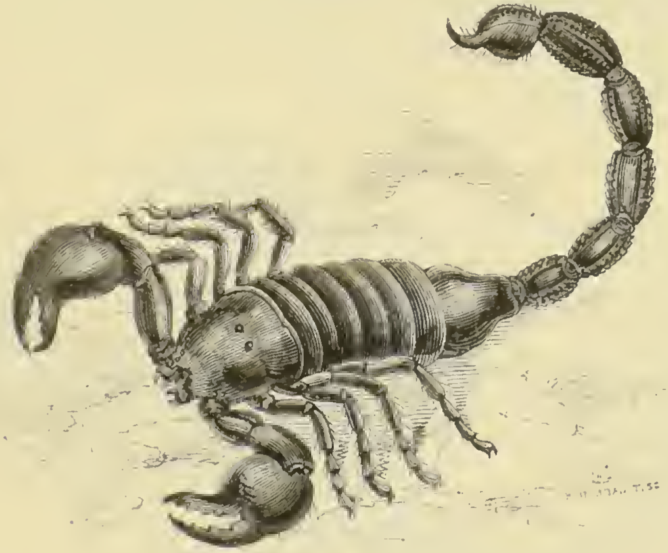
the chief business of their lives is devoted to rapine and bloodshed.

The scorpions (fig. 81) have something in their physiognomy, which at once proclaims them to be remorseless, treacherous ruffians, at whose approach hope may

> "Withering fly, and mercy sigh farewell!"

Before discussing their habits, however, we must consider them for a moment in a zoological point of view, because, as the reader will perceive at a glance, their whole structure is not a little remarkable. We have stated above that all arachnidans, in their adult state, have only four pairs of legs; but the reader will, perhaps, be inclined to imagine, on looking at the last figure, that the scorpion has five pairs, the pair in front being of enormous size,

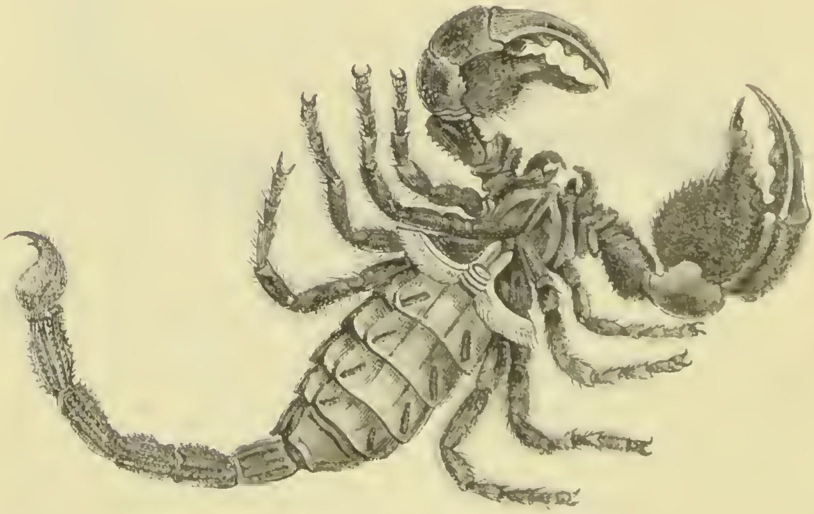
Fig. 81.



and like the claws of a lobster terminated by formidable pincers. In this, however, he would be mistaken; the four hinder pairs alone are real legs adapted for walking, while the anterior pair are not legs at all, but appendages to the jaws, the representatives of the maxillary palpi of insects (*vide* fig. 4), here so enormously developed as to have the appearance of feet; hence the whole tribe of scorpions are designated by naturalists "pedipalpi" or "foot-palp arachnidans."

In order to enable the creature to wield these prodigious weapons, it is evident that the posses-

Fig. 82.



sion of a slender neck, like that of an insect, intervening between the head and the thorax, would be inadmissible; the head and the thorax are, therefore, firmly consolidated into one piece, and thus sufficient strength is afforded to sustain such weighty limbs, whereby the prey is seized and crushed preparatory to its being conveyed to the mouth.

The mouth itself is a very strange apparatus. Instead of being furnished with jaws like those of an insect, it is provided on each side with a pair of small forceps, resembling the pedipalps in miniature, and apparently calculated to act the part of hands while the creature feeds itself.

The legs are all attached to the fore-part of the thorax, while beneath the hinder segments are situated the four pairs of breathing holes. In front of the respiratory apparatus is placed a curious pair of organs called "the *combs*" (fig. 82), instruments apparently provided for cleaning the breathing holes, and thus preventing any obstruction to the free passage of air required for respiration.

Lastly, comes the elongated abdomen resembling a long tail, at its extremity supporting the terrible *sting* of the scorpion; a fearful weapon terminated by a sharp hook, having its point directed backwards. The enlarged portion of the terminal joint contains a bag wherein a poison is secreted scarcely less virulent than that of the viper, ready to be infused into any puncture made by the needle-like point of the sting, and so fatal in its action as to cause the instant death of an insect-victim; even upon man himself the wounds inflicted by this fearful sting have been productive of serious consequences.

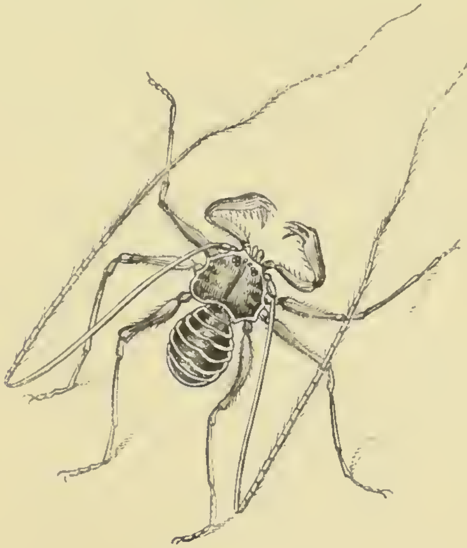
Thus provided, the scorpions prowl about in search of prey, hiding themselves during the daytime beneath stones or blocks of wood, where they find food enough adapted to their taste; in the night-time they become more venturesome, and not unfrequently enter the houses of the inhabitants of countries where they abound, proving, as we should apprehend, anything but welcome visitors.

These formidable intruders are very active in their movements, they run quickly, carrying their tail curved forwards over the back, or brandishing it in all directions when inclined to use it as a weapon, either for defence or attack. They seem to be very quicksighted, but both in their structure and arrangement the eyes of these creatures are widely different from those with which the true insects are furnished. Instead of being composed of many facets, sometimes amounting to thousands in number, the scorpion is provided with six or eight simple eyes, placed upon the anterior part of the back, and constructed after the same plan as those of the spider hereafter to be described.

These eyes, in the living animal, gleam like those of a cat, and are adapted to discover prey even in the obscure haunts that the creature frequents. In the selection of its victims it is by no means particular; beetles of all sorts, wood-lice, grubs, and cricket, are equally acceptable; a puncture with the fatal sting soon puts them to rest, after which they are transferred to the smaller pairs of forceps in the vicinity of the mouth, to be sucked until all the nutriment they contain is exhausted. The eggs of insects and of spiders likewise, seem to be favourite delicacies, so that vast must be the destruction caused by these armour-clad tigers amongst the various races they are appointed to devour.

Nearly allied to the scorpions in their general structure, but differing from them in the shape of the abdominal portion of their bodies, which is broad and flat, are the Arachnidans, composing the genus *Tarantula* of Fabricius,* many species of which are remarkable on account of the extraordinary modifications of form observable in their anterior limbs, rendering them objects of deep interest to the scientific zoologist. In the subgenus *Phrynus*, for instance (fig. 83), the pedipalps in their proportionate size and strength almost emulate those of the scorpion, only instead of pincers they are terminated by sharp and powerful hooks, the gripe of

Fig. 83.



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* These must not be confounded with the tarentula spider (*Lycosa tarentula*), so celebrated among the Italians for its venomous bite, only to be cured, as fables tell, by the aid of music and dancing.

which must be truly formidable; immediately behind these is situated a pair of limbs, which, from all analogy, ought to constitute the first pair of ambulatory legs, but which, in reality, have much more the appearance of enormous antennæ, the tarsi being represented by a numerous series of slender segments so nearly resembling the setiform antennæ of some insects that it is impossible not to assign to them a similar office; while the six posterior legs present nothing unusual in their structure. The superficial observer might, indeed, easily mistake these for true insects, did not the rest of their structure amply testify their arachnidan character.

The ARANEIDÆ, or SPIDERS, are at once distinguishable from all other arachnidans by the possession of a wonderfully constructed apparatus of spinning organs, whereby they are enabled to manufacture the delicate silken threads of which their well known "webs" are woven. It is indeed from this faculty of spinning, although bestowed only upon the true spiders, that the entire class has received its name, the original Greek word *ἀράχνη* meaning a spider remarkable for its skill in weaving, such as that into which the unfortunate Arachne was said to have been metamorphosed by her goddess-competitor in the art.

On examining the structure of a spider with a little attention, the first thing that strikes the naturalist is the remarkable compactness of its form. Its head and thorax are found to be conjoined into an almost circular disc, around which the legs and parts of the mouth are implanted, like radii diverging from the centre of a circle, while the abdominal segments are collected into a globular mass, attached by a narrow pedicle to the posterior margin of the thorax.

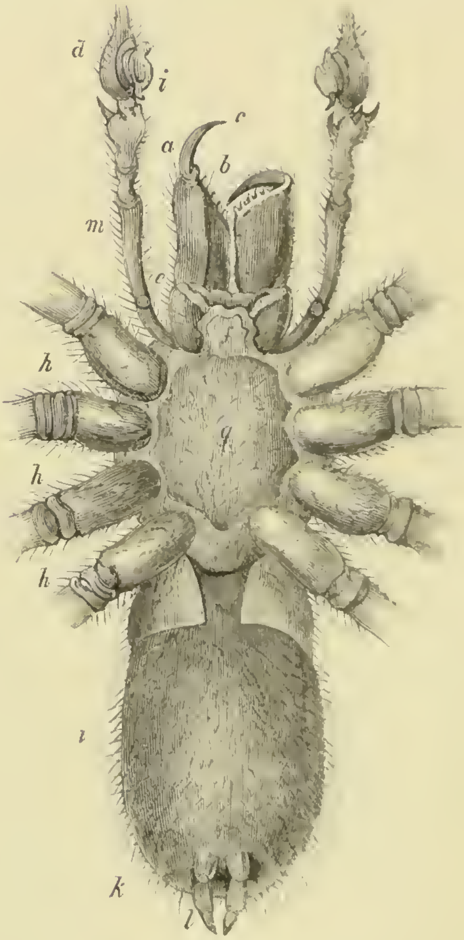
Its eight locomotive limbs are likewise of very peculiar contrivance, and so arranged that the feet are exactly disposed to play upon the cords of its web, and

> " With a touch, how exquisitely fine !
> Feel at each thread, and live along the line !"

The palpi (fig. 84, *m*) are not, like those of the scorpion, weapons of attack, although still inordinately developed, and in the male spiders they are terminated by a very singular club (*d*), which does not exist in the female.

No one, we apprehend, who looks at the armature of a spider's jaws can mistake the intention with which this terrible apparatus was planned. " Murder " is engraved legibly on every piece that enters into its composition. The mouth, which is only adapted to suck the blood of its victims, is bounded inferiorly by a horny plate, or *labium* (fig. 84, *f*), and is furnished with two side pieces (84, *e*), above which are situated the formidable jaws. Each of the latter consists of two pieces, one of them (*e*) serving as a basis to support the powerful fangs (*a*, *b*, *c*), articulated by means of a strong joint to its extremity. On examining the fang attentively with a good lens, it is seen to be perforated near its apex in the same manner as the sting of the scorpion, the minute orifice being the termination of a narrow canal, derived from a bag of subtle venom. A very slight inspection of the figure will enable the reader to understand the intention of these deadly weapons. The poor insect to be devoured is

Fig. 84.

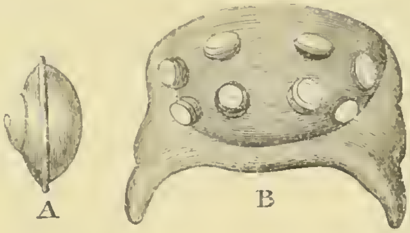


first seized by the fangs (*a*, *b*, *c*), which, grasping it with the strength of a vice, soon pierce its frail armour, and at the same time instil into the wound a drop of poison, almost instantly fatal in its effects.

The fangs are then bent down, crushing the prey against the toothed margin of the jaws so as to squeeze it until its juices are exhausted.

The eyes of spiders seem to be analogous to the simple ocelli with which some insects are furnished in addition to their compound visual organs. They are generally eight in number, arranged in such a manner that the axes of all are turned in different directions, as represented in the annexed figure (fig. 85, B). The four situated upon the top of the head are inclined obliquely upwards, but all at opposite angles; two others look directly sideways, one towards the right, and the other towards the left, whilst the remaining two are pointed forward; their structure, moreover, very nearly resembles that of vertebrate animals (fig. 85, A), so that doubtless the sight of these creatures is extremely perfect.

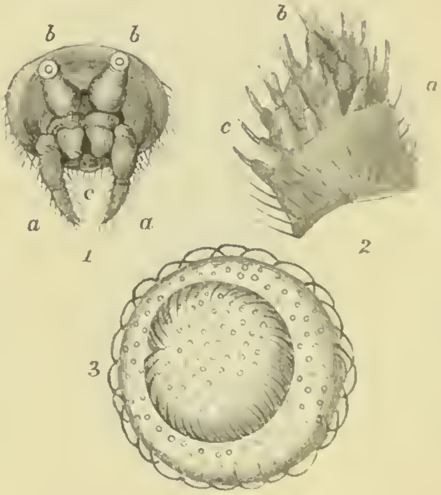
Fig. 85.



The most characteristic part of the economy of the spiders yet remains to be described, namely, the machinery wherewith they are provided for the construction of their silken lines, and the various uses to which these threads can be appropriated.

Every one is familiar with the appearance of the delicate filament of which the web of the spider is manufactured, yet few are in the habit of adequately appreciating this wonderful fabric. To the unassisted eye the spider's line appears to be a simple filament, only remarkable for its inexpressible tenuity, and they little think that this almost invisible thread is positively a rope, composed of as many strands as are needed in constructing the cable of a first-rate man-of-war, and the machinery employed in making it, although much more elegant, is quite as elaborate as any to be met with in Plymouth dock-yard. In order to demonstrate the accuracy of this assertion, it is only necessary to inspect the spider's ropery, which, with a little patience, and the assistance of a good microscope, will be found to answer to the following description.

Fig. 86.

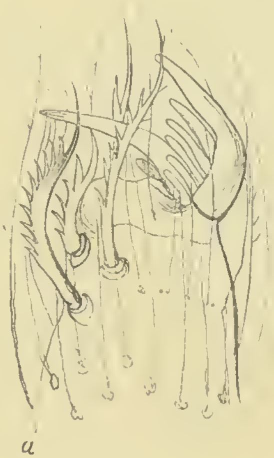


The spinning apparatus consists of four minute barrel-shaped organs (fig. 86, 1, *b*, *b*, *c*), close to which, but situated a little lower down, are a pair of jointed feeler-like appendages (*a*, *a*).

The extremity of each of the upper pair of spinnerets (*b*, *b*), seen under the microscope, is found to have the structure delineated in fig. 86, 3. Its circumference is encompassed with a raised margin, which is slightly rounded, and surmounted by a circle of hairs or slender spines, having their points all curved inwards. Within the hairy margin there is another circle of hooked spines, while the whole surface of the extremity of the spinneret, representing the head of the barrel, is perforated with a vast number of little holes of indescribable minuteness, through each of which a filament is drawn during the formation of the thread.

The construction of the two other spinnerets (*c*) is different, for although these are in like manner perforated with numerous apertures resembling those of the preceding pair, they are also provided with prominent tubes (fig. 86, 2, *a*, *b*, *c*), from each of which a thread is likewise furnished.

Fig. 87.

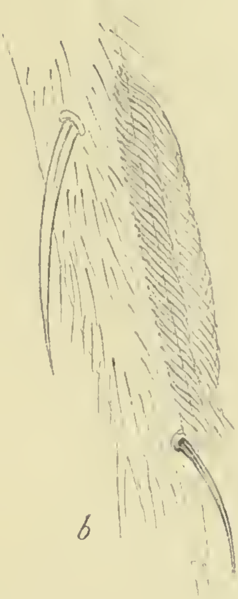


Within the body of the spider are situated numerous delicate bags filled with liquid silk, that, at the pleasure of the animal, can be made to exude through the countless orifices we have been describing. When, therefore, the creature wishes to form a rope, it simply applies the ends of its spinnerets to a fixed object, and drawing a filament of fluid silk through every pore, its line of course consists of as many threads as there are holes in the perforated plates of its four barrel-like colanders.

The feet of a spider are constructed upon a very singular plan, evidently in relation with its rope-dancing capabilities. Each foot, when considerably magnified, is seen to be armed with strong horny claws (fig. 87, *a*), furnished along their under surface with about a dozen bent teeth, placed in a row, and gradually diminishing in size as they approximate the extremity of the claw. By means of this apparatus the spider is enabled to regulate the issue of its rope from the spinnerets, disposing it in the required manner; and also to suspend itself by its almost invisible line, coiling it up, or letting it out at pleasure, with a facility and neatness that must excite the admiration of any one who attentively watches these operations.

In addition to the above remarkable mechanism of the feet, there exists in some genera of web-spinning spiders a remarkably constructed combing machine. In *Clubiona atrox*, a species everywhere to be met with, building its snares upon the branches of trees and shrubs growing against buildings, in the crevices of old walls, or in the corners of windows; this consists of two parallel rows of spines, moveable at the pleasure of the animal, situated on the upper joint of the tarsi of the posterior legs, upon a prominent ridge, commencing just below its articulation with the tibia, and terminating in a strong spur near its lower extremity: with this singular organ the clubiona diligently employs itself in combing out certain fibrous bands that enter into the composition of its web, for, delicate as it is, the spider's net is by no means constructed of the same material throughout.

Fig. 88.



According to Messrs. Kirby and Spence, the web of the garden spider is composed of two distinct kinds of silk; that of the radii not being adhesive, while that of the circles is extremely viscid; a difference, they remark, when it is considered that both sorts proceed from the same instrument, which is truly wonderful. It appears, however, from the researches of Mr. Blackwall,* that the fact is even more extraordinary than it has been represented by the distinguished naturalists alluded to, for not only the garden spider but the geometric species generally, employ *three* distinct kinds of silk, if a liquid gum can with propriety be called silk, in the construction of their nets. The boundary lines, radii, and first formed spirals being unadhesive, and possessing only a moderate share of elasticity, are evidently composed of a different material from the spiral line that completes the web, which is exceedingly viscid, and elastic in a remarkable degree. The viscidity of the elastic spiral line may be shown to depend entirely upon a series of globules resembling tiny beads, for if these be removed by the careful application of the finger, a fine glossy line remains, which is highly elastic, but perfectly inadhesive. As the globules, therefore, and the line on which they are disposed, differ so essentially from each other, and from the rest of the snare, Mr. Blackwall reasonably infers that the physical constitution of these several portions of the net must be dissimilar.

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* Linn. Trans. vol. xvi. p. 479.

An estimate of the number of viscid globules distributed on the elastic spiral line in a single net of medium size, will serve to convey some idea of the elaborate operations performed by the geometric spiders in the construction of their snares, not fewer than 87,360 having been calculated by Mr. Blackwall upon a web of ordinary dimensions, each of which is separated from those adjacent to it by a sensible space; indeed the material of which they are composed is so fluid, that they run together the moment they are brought in contact; and yet one of these nets does not occupy the spider longer than about forty minutes in its construction. It is upon the presence of these viscid globules that the retentive power of the web seems to depend; for when exposed to the desiccating influence of the sun, and of air briskly agitated, the nets of geometric spiders speedily lose their adhesive property; but when found in situations from which light is excluded, and where the atmosphere is not liable to be disturbed, they will retain their viscidity for a long period.*

A very obvious reflection will here naturally suggest itself in connexion with this beautiful machinery; why in the case of the spider it has been found necessary to provide a rope of such complex structure, when in so many insects a simple undivided thread drawn from the orifice of a single tube, like the thread of the silk-worm, for instance, was sufficient for all required purposes. And here, as in every other case, it will be found on consideration, that a complicated apparatus has been substituted for a simple one only to meet the requirements of strict necessity. The slow-moving caterpillar, as it leisurely produces its silken cord, gives time enough for the fluid of which it is formed to harden by degrees into a tenacious filament, as it is allowed to issue by instalments from the end of the labial pipe; but the habits of the spider require a very different mode of proceeding, as its line must be *instantly* converted from a fluid into a strong rope, or it would be of no use for the purposes it is intended to fulfil. Let a large fly, for example, become entangled in the meshes of the spider's web, no time is to be lost; the struggling victim by every effort to escape is tearing the meshes that entangle it, and would soon succeed in breaking loose did not its lurking destroyer at once rush out to complete the capture, and save its net, spun with so much labour, from ruin. With the rapidity of thought it darts upon its prey, and before the eye of the spectator can comprehend the manœuvre, the poor fly is swathed in silken bands, until it is as incapable of moving as an Egyptian mummy. To allow the spider to perform such a feat as this, its thread must evidently be instantaneously placed at its disposal, which would have been impossible had it been a single cord, but being subdivided into numerous filaments so attenuated as we have seen them to be, there is no time lost in the drying, from being fluid they are at once converted into a solid rope, ready for immediate service.

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* Every one has doubtless observed this beaded appearance of the spider's webs, when covered with dew-drops on a sunny morning, and admired the gorgeous tints which they emit. The Rev. Dr. Scoresby, alluding to this phenomenon, observes:—"Sometimes, where the breadth of the web was considerable, most of the colours of the spectrum have been observed on the same surface, in regular and beautiful series; and these colours made to shift or vanish, as in some optical experiments with polarizing instruments, with surprising effects in beauty."

In cases where the spider's lines are not very compact, the appearance of the highly illuminated minute globules of moisture is that of various strings of brilliantly coloured gems, disposed in radiating lines;—strings, as of the topaz, diamond, aquamarine, sapphire, emerald, and amethyst, were dispersed in splendid association over the surface, whilst each series is, as if magically, altered into some other, by the slightest lateral movement of the eye of the observer.

Such is the structure of the spider's line, and the mode of its production; still, whether composed of one strand or a thousand, it is merely a thread, and we must next proceed to inquire for what various purposes it may be employed. It was a grand step in the history of the human race, when man first constructed a thread adapted to be employed in his manufactures, and much has human ingenuity achieved in perfecting various textile fabrics required for innumerable uses, yet we question whether the products of the loom will bear comparison with the webs constructed by some of our arachnean weavers.

Among the most common of our native spiders are the manufacturers of the well-known gossamer films, which on a fine autumn morning may sometimes be seen covering the ground with their meshes, or floating in the air in immense numbers. These threads, called by the French, "fil de la vierge," so much astonished our forefathers by their immense numbers that they supposed them to be the scum left by dew dried in the sun; and Robert Hooke, one of the earliest microscopists, although by no means a despicable observer, and a Fellow of the Royal Society to boot, in his celebrated "Micrographia," speaks of "a certain white substance, which after a fogg may be observed to fly up and down in the air;" and goes on to say, "catching several of these, and examining them with my microscope, I found them to be much of the same form, looking much like a flake of worsted prepared to be spun; though by what means they should be generated or produced is not easily imagined: they were of the same weight, or very little heavier than the air; and 'tis not unlikely that those great white clouds, that appear all the summer time, may be of the same substance."(!!)

It appears to have been Dr. Martin Lister who first discovered the real nature of these flakes, and found that, instead of being dried dew or fragments of clouds, they were merely the threads spun by little spiders, whereby they are enabled to mount into the air, riding on these subtle filaments; he noticed, moreover, that they were able to pull in their long threads with their fore-feet, so as to form it into a ball, upon which they floated as in an air-balloon to a prodigious height in the atmosphere. It appears from observations that this faculty seems to be possessed by many species of spiders, but only in their young or half-grown state, while their bodies are sufficiently light to be conveyed in this remarkable manner. Sometimes one spider may be noticed darting out several threads, which look like so many shining rays in the tail of a comet.

Gilbert White, in his "Natural History of Selborne," speaks to similar facts:—"Every day in fine weather in autumn," says he, "do I see these spiders shooting out their webs and mounting aloft; they will go off from the finger if you will take them into your hand; last summer one alighted on my book as I was reading in the parlour, and running to the top of the page, and shooting out a web, took its departure from thence. But what I most wondered at was, that it went off with considerable velocity in a place where no air was stirring, and I am sure I did not assist it with my breath. So that these little crawlers seem to have while mounting some locomotive power without the use of wings, and move faster than the air in the air itself."

From subsequent experiments on this subject, made by Mr. Blackwall and others, it appears, however, that the gossamers have no power of forcibly shooting out their threads, but that they simply emit from their spinning apparatus a small quantity of the glutinous secretion wherewith the thread is formed, and this being drawn out by the ascending currents of rarified air into fine lines, several feet in length, is carried upwards until the little spiders, feeling themselves acted upon with sufficient force in that direction, quit their hold of the objects on which they may be standing, and thus commence their journey aloft. Whenever these lines become unfit for the intended purpose, by adhering to any fixed body, for instance, they are immediately detached from the spinnerets by means of the last pair of legs; and seeing that this material is thus produced in such quantities, it is not surprising that when it falls to the earth, the ground seems almost carpeted with gossamer threads.

Next come the *sedentary spiders*, remarkable for weaving large webs wherewith to entrap insects, and lying in wait in the centre or near the side, until some hapless victim is entangled in their toils. Various are the forms of these ingeniously constructed snares; some are of a close texture, such, for example, is that of our common house-spider (*Tegenaria domestica*), which builds in the angles of walls, or upon hedges, or upon the ground under stones. These webs are broad expansions, spread out horizontally, as though to afford a resting-place to any passing fly, but at the upper part the spider lurks unseen, patient and motionless as death, ensconced in a silken cave, from which he darts as with the tiger's spring, on the unsuspecting traveller that has unhappily yielded to the temptation, and there thought to rest his wearied wings.

Who has not admired the patient labour of the *geometric spiders,* as they are not inaptly named, which spread abroad their webs, of regular and open texture, nets to catch the merry dancers of the sunshine hours! By what rule are they instructed so to build? What compasses have they to guide them in the adjustment of each line, as mesh to mesh is added? Wondrous fabric! These spiders generally station themselves without any concealment in the centre of their nets, where they hang head downwards, ready to dart off to any part and grapple with the struggling prey: some species, however, conceal themselves either in silken tubes, or under a shelter made of leaves, ingeniously tied together.

The habits of the web-spinning spiders vary considerably; many of them, hence known by the name of "hunting spiders," are incessantly running or leaping about in the vicinity of their abode, to chase and catch their prey: of these, several species hide themselves in holes or fissures, which serve as their dens; others enclose themselves in silken tubes, or shelter themselves in small cells. Some hunt their food like greyhounds, by running it down, whilst others leap or spring upon it with the agility of cats.

One of these may frequently be seen in summer time upon the sides of sunny walls, running with a sort of hop-skip-and-jump motion, advancing a few paces, and then suddenly stopping to rear itself up on its fore legs. Should it in its progress chance to discover a gnat or little fly, it approaches it as stealthily as a cat, and having got sufficiently near, springs with one bound upon its helpless victim; it does not hesitate even to leap upon its prey by springing directly from the wall, for seeing that it always spins a rope behind it wherever it moves, it cannot fall to the ground, but soon scrambles up again to the place whence it took its apparently perilous leap, or it allows itself to be driven by the wind from place to place.

These leaping spiders construct their domiciles by spinning little silken bags of an oval shape, and open at both ends, concealed in folded leaves, or under stones, into which they creep to repose, to change their skins, or during inclement weather, and if disturbed in their retreat, they scamper off with remarkable agility. In like manner the females prepare a kind of tent in which to rear their young, which live for some time in this nursery, under her maternal care.

A very remarkable abode constructed by the "hunting spider," belonging to the genus *Mygale*, must not be passed over in silence, for no robbers' den ever described by writers of romance could be more secure from observation, or afford a safer retreat. The nests in question are deep wells sunk to the depth of at least a foot into the ground, their sides being lined throughout with solid masonry, and the entrance defended with a trap-door of very cunning workmanship that has to be raised whenever the spider wishes to leave or to enter its dwelling.

When we consider that these deep wells have to be entirely excavated, lined, and furnished by the unassisted labour of a single spider, it becomes a matter of wonder how such works could ever be achieved, and our surprise must necessarily increase when we reflect upon the difficulties that have to be surmounted, and the apparent want of all tools adapted for the completion of such an undertaking.

If a man were ordered to dig a well thirty feet deep, and five or six feet in diameter, by his own unassisted labour, and line it throughout with bricks, he would consider it almost a hopeless task; and if he were further directed to dig this well in a sandy soil, without the aid of any tools but his own hands, he would doubtless give it up in despair. Such, however, is precisely the task imposed upon the spider, and how she manages to accomplish it we must next proceed to inquire.

Having selected a spot adapted to her purpose, she first marks out the mouth of her excavation by a circular web of silk, with which she intermixes particles of earth, so as to construct a boundary wall, circumscribing the future aperture of her den, and serving as a barrier to prevent the loose soil from falling in—she then proceeds to dig, and as she brings the earth out supports the sides of her well by prolonging the wall of silk into the hole she forms, and thus binds together the soil which has to be the side of her house, so as to convert it into a solid wall; in this way she goes on bringing load after load out of her pit, and as it sinks deeper and deeper, continuing her silken masonry downwards, until she has reached the required depth of a foot or more beneath the surface. When thus completed the wall is a strong tube, about an inch in diameter, and sufficiently firm to be dug out entire. Her next operation is to line the walls of her tube with a very beautiful tapestry of a very firm texture, something like tissue paper, or, as it has been well described by a pleasing writer, something intermediate between Indian paper and glove leather.* "But the most wonderful part of this nest is its entrance, which we look upon as the perfection of insect architecture. A circular door about the size of a half-crown piece, slightly concave on the outside, and convex within, is formed of more than a dozen layers of the same web, which lines the interior, closely laid upon one another, and so shaped that the inner layers are the broadest, the outer being gradually less in diameter excepting towards the hinge, in which direction the lid is about an inch broad, and in consequence of all the layers being united there, it becomes the thickest and strongest part of the structure. The elasticity of the materials, moreover, gives to this hinge the remarkable peculiarity of acting like a spring, and shutting the door of the nest spontaneously. It is, besides, made to fit so accurately to the aperture, which is composed of similar concentric layers of web, that it is almost impossible to distinguish the joining by the most careful inspection. To gratify curiosity, the door has been opened and shut hundreds of times, without in the least destroying the power of the spring. When the door is shut it resembles some of the lichens (*Lecidea*), or the leathery fungi, such as *Polyporus versicolor*, or nearer still, the upper valve of a young oyster shell." The whole nest is of a blackish brown colour, and the lid so accurately resembles the surrounding soil that to detect it is almost an impossibility, even to the scrutinizing eyes of the entomologist.

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* Insect Architecture, p. 361.

The tent of another spider, described by M. Dufour (*Clotho Durandii*), is, perhaps, as ingeniously contrived a residence as any of the various habitations constructed by these indefatigable weavers. The spider, in question, spins its web on the under surface of some large stone, or in the crevices of rocks. This web is about an inch in diameter, and has somewhat the appearance of a limpet, its circumference being indented with seven or eight deep notches, of which only the prominent angles are fixed to the stone, while the rest of the margin is free. The texture of the cloth of which this remarkable tent is formed is very beautiful, resembling the finest taffeta, laid on in several sheets, the number of which is increased in proportion to the age of the spider. Thus, when the young Clotho first sets up housekeeping, it constructs only two layers, between which it conceals itself, but afterwards, as it grows older, it continues to add other layers to the fabric. At last, when about to lay her eggs—for it is the female only that makes these singular nests—she spins an apartment intended for her nursery, more fleecy, softer and warmer than the rest, for the reception of her young brood. The outer layer of the tent is intentionally made dirty and soiled, so as to make it scarcely perceptible among the surrounding objects, but within, everything is exquisitely clean and white. The eggs are deposited in four or five separate cells, all appearing as if lined with the finest eider-down, for as the eggs are laid in the beginning of winter, this warm covering is necessary to defend them against the severity of the season, as well as from the attacks of enemies, and nothing could be better contrived for both purposes. The chamber containing the eggs is, in the first place, separated from the surface of the cold stone by a downy blanket, and kept warm above by the several layers of soft taffeta; but the most beautiful part of the arrangement is the contrivance by which the spider is enabled to leave her nest without the possibility of any intruder getting in during her temporary absence.

This is managed as follows. Among the indentations around the margin of the pavilion, some are entirely closed by stitching together the edges of the different silken sheets, whilst others are left unsewn, so that their edges are only laid together, and by lifting them up the spider can get in or out as she pleases, and when she goes from home to hunt for prey, she need fear no intrusion in her absence, for as she alone knows the secret of her domicile, no animal, unpossessed of such a key, can find admission into the interior of her impenetrable tapestry.

When the young are sufficiently strong to do without her maternal care, they leave the tent of their parent and proceed to construct their own private residences, while the mother soon dies, the cradle of her offspring serving likewise for her own tomb.

The *vagabond spiders* are always wandering abroad and incessantly spying about in search of a victim. These are further distinguished by walking or running sideways or backwards, and seem to have no fixed residence, except at the time when they lay their eggs.

These *side-walking spiders*, as they are sometimes named, are generally met with upon the ground, where they run with great swiftness. They live, for the most part, in any hole that they may find adapted to their purpose, which they make more comfortable by lining it with silken tapestry. Some species, indeed, select cracks and cavities in old walls, in which they construct their silken tube-like retreats, which, however comfortable within, are under these circumstances carefully concealed by being completely covered externally with dirt and sand; here they reside and pass the winter, having first carefully closed up both ends of the tube.

It is not merely in the construction of their residence that these spiders turn their silken filament to account; with its assistance they are enabled to fabricate a cradle for their progeny, so well contrived that it is impossible to contemplate it without admiration, or without reflecting that even amongst these most savage and ferocious of all living animals, " Love, strong as Death," has been appointed the safe-guard and defender of the race. Who would expect anything like affection in a female spider, remorseless, cruel, and blood-thirsty as she is? Her very mate approaches her with fear and trembling, for should she not happen to be in an extremely good temper, his life inevitably pays the forfeit of his rashness, his amiable spouse feeling not the slightest objection to obtain a hearty meal by devouring her better half; yet, strange to say, no animals can be pointed out more devotedly attached to their progeny than the females of these relentless devourers. When about to lay her eggs, converting her silken thread to a new use, the spider-mother constructs with it a beautiful globular basket or cocoon, in which she deposits her precious treasure, and then binds the cradle to some part of her body, or sometimes simply carries it clasped to her breast: no matter how she may be engaged, she never leaves it, even while at the chase in search of food; no danger, no torture will make her drop her cherished burden, nor while life lasts will anything compel her to desert the charge entrusted to her care. When the young are hatched the spectacle is equally interesting, for the new-born progeny, as they leave the egg, creep out upon their mother's back, who carries them about and defends them with tiger-like courage until they become strong enough to procure their own subsistence.

Many spiders, like some of the insect tribes, are possessed of the power of walking up the perpendicular surfaces of polished bodies, such as vertical panes of well-cleaned windows, or the sides of glass jars, a faculty for which they have generally been considered indebted to the silken lines they are able to emit from their spinnerets; but this, as Mr. Blackwall assures us, is by no means the case. The feet of all spiders enjoying this power were ascertained by that gentleman to be provided with a very wonderful prehensile apparatus, consisting of slender bristles, fringed on the sides with exceedingly fine hairs, that gradually diminish in length as they approach its extremity, where they occur in such profusion as to form a thick brush on its inferior surface, giving that part a dilated appearance. At a very low estimate there are on the slender bristles which form the brushes, occurring on the inferior part of the tarsi and the terminal joint of the foot-like palpi of adult females of the species *Mygale avicularia*, more than six millions of these minute hairs, a large proportion of which can be applied by the spider to bodies with plain surfaces. The hold upon objects which this apparatus affords seems to be purely mechanical, depending in a great measure on the numerous points of contact they present; and if the finger be drawn gently along the under side of the tarsi, from their extremities towards the tibiæ, they will be fonnd to adhere powerfully to the skin; the sensation occasioned by this proceeding exciting in the mind the idea that they are smeared with some viscous matter.

Spiders, unlike the true insects, frequently change their skin, and present themselves in a new and enlarged dress as their growth proceeds. The manner in which this operation is effected is thus described by Mr. Blackwall, to whose excellent observations on the structure and economy of these creatures we must again be indebted for an account of the process. "Preparatory to casting its integuments, the spider spins several strong lines in the vicinity of its snare, from which it suspends itself by the feet, and a filament proceeding from the spinners. After remaining for a short time in this situation, the horny covering of the thorax gives way by a fissure running down each side of the body, immediately above the insertion of the mandibles and legs, so that the head and thorax are the first parts liberated. The line of separation pursues the same direction till it extends to the abdomen, which is the next part disengaged; the extrication of the legs being the last and greatest difficulty the spider has to overcome. As the suspensory filament connected with the spinners of the exuviæ is considerably shorter than the legs, and does not undergo any sensible alteration in length, the abdomen during the process of moulting becomes gradually deflected from its original horizontal direction, till it assumes a vertical position nearly at right angles with the thorax. By this change of posture, attended with numerous contortions of the body, and alternate contractions and extensions of the limbs, the spider is ultimately enabled to accomplish its purpose. The spines with which the legs are provided no doubt contribute to facilitate the operation greatly, for as they are directed down the limbs, and are moveable at the will of the animal, when it has partially drawn its legs from their sheath, by contracting them, it can prevent them from re-entering by slightly erecting the spines, and thus bringing their extremities in contact with the inner surface of the integuments. When the spider has completely disengaged itself from the slough, it remains for a short period in a state of great exhaustion, suspended solely by a thread from the spinners, connected with the interior of the abdominal portion of the cast skin, which is much corrugated and drawn together. The entire process, as above described, occupies the space of about twenty minutes. After reposing a little, the spider further attaches itself to the suspensory lines by the claws of the feet, and when its strength is sufficiently restored, and its limbs have acquired the requisite degree of firmness, it ascends its filaments and seeks its retreat."

CHAPTER XVII.

CRUSTACEA.

Fathomless Ocean! countless are the multitudes of living things rolled over by thy billows; infinite the host of strangely fashioned creatures that disport themselves throughout thy vast domains unseen by man, yet not on that account less decked with rainbow-hues, less varied in their attributes, less admirably contrived than those that live on land, or people air with gay inhabitants. Of all the insect legions, not one can be called an inhabitant of the sea,* all are terrestrial — even those frequenting ponds and ditches of fresh water must respire the atmosphere we breathe, by coming to the surface at short intervals in search of air; but in the deep abysses of the ocean, such a mode of respiration would be obviously impossible; even near the shore, or at small depths, the constant agitation of the waves would speedily submerge all creatures breathing air, and plunge them far beyond the influence of the vital element.

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* There is one remarkable apparent exception to the general law that no insect inhabits the sea—namely, in the case of *Blemus fulvescens*, a little beetle which passes much of its time in the ocean, at a distance from the shore, and at a considerable depth from the surface; it has the adroitness to place itself under some stone when the tide is out, where there is a cavity left filled with air; after the water has returned, therefore, the retreat of the insect is converted into a sort of diving-bell, in which it keeps itself snug till the retiring waves set it at liberty.

If then the world of waters is to have its insect forms of life, important changes must be made in their entire economy, adapting them to live in water, which must be their medium for respiration, even at depths remote from all immediate intercourse with the atmospheric fluid. Such are the beings that compose the next great class of animals that courts our notice—a class as numerous as any we have hitherto encountered.

The first grand character distinguishing these insects of the sea from real insects, or arachnidans, is found in the material whereof the jointed armour, their integument, consists, the shells of the *Crustacea* being composed, for the most part, of carbonate of lime and other earthy salts, giving them, in the larger species, great solidity and strength, and forming a dense crust from which the class derives its name.

Secondly, while the true insect in its perfect state is never provided with more than six legs, all attached to the thoracic segments of the body, and the arachnidan possesses eight locomotive limbs similarly disposed, the crustacean presents us with numerous pairs of legs, as various in their shape and disposition as in the uses to which they are applicable.

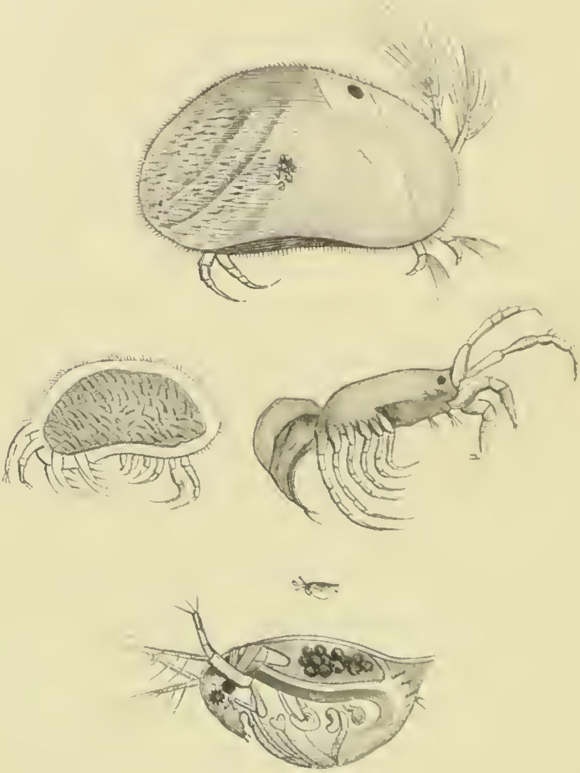
Thirdly, all the tribes of insects and arachnidans are strictly air-breathing animals, respiring either by means of tracheæ, or of the pulmonibranchiæ described in the last chapter; but the respiratory apparatus of the crustacean is adapted to breathe only through the medium of water, and even in those species that are most terrestrial in their habits, moisture is essential to enable them to respire.

We will begin our account of the members of this extensive class, by describing those which inhabit the fresh waters around us, swarming in every pond and ditch in countless myriads, and consequently interesting to the naturalist from the very frequency of their occurrence.

Various are the forms of these active little creatures, and strange the history of some of them. One numerous group, everywhere to be met with in great abundance, contains the creatures vulgarly designated water-fleas (*Cyclops*, *Cypris*, *Daphnia*, &c., fig. 90, 1, 2, 3) which, from their odd forms and agile movements, are always entertaining objects for the young microscopist. The cyclops, so called from possessing apparently only one eye, has ten legs, but makes use of its antennæ, which are in the generality of the crustacea four in number, as organs of locomotion, and also as a means of procuring food, striking the water with them continually, and in this way driving towards its mouth the materials upon which it feeds. The cypris (fig. 90, 2) or water shell-flea, has its body enclosed in two shell-like plates, joined together by a hinge, running along the middle of the little creature's back, so that the two valves can be opened or closed at pleasure, and its legs thus protected between these singular shields.

In Daphnia (fig. 89) the lateral shell-like plates are also present, but there is no dorsal hinge, so that swimming can here only be accomplished by the active movements of the four antennæ.

Fig. 89.



Throughout the whole group there is no appearance of any internal or external apparatus specially appointed for respiration: the rapidly moving little legs and antennæ are, however, easily seen with a slight magnifier to be decorated at intervals with delicate tufts of long hairs, generally looked upon as affording a respiratory surface, yet even this seems improbable, as similar tufts exist in higher forms, where they are evidently merely given for the purpose of performing the office of paddles: such indeed is the minute size of the entire creature, and such the thinness and delicacy of the external tegument, that the legs themselves doubtless perform the office of branchiæ, and by their rapid movements, continually change the water in which they are immersed.

The numbers of these minute creatures met with in stagnant waters are, at certain seasons of the year, quite amazing, insomuch, indeed, that they colour the ponds with the tints of their own bodies, so that even from their multitudes their agency in creation must be important. Passing over their being the food of innumerable other animals, we cannot but perceive how great must be the influence of all their hungry legions in purifying, and so preserving from putrefaction, the ponds and marshes where they thus abound. Their nourishment consists of all decaying particles, animal or vegetable, which they eat voraciously, so that their hungry jaws, continually at work, devour the products of decay, and aid in the great task of keeping clean the world.

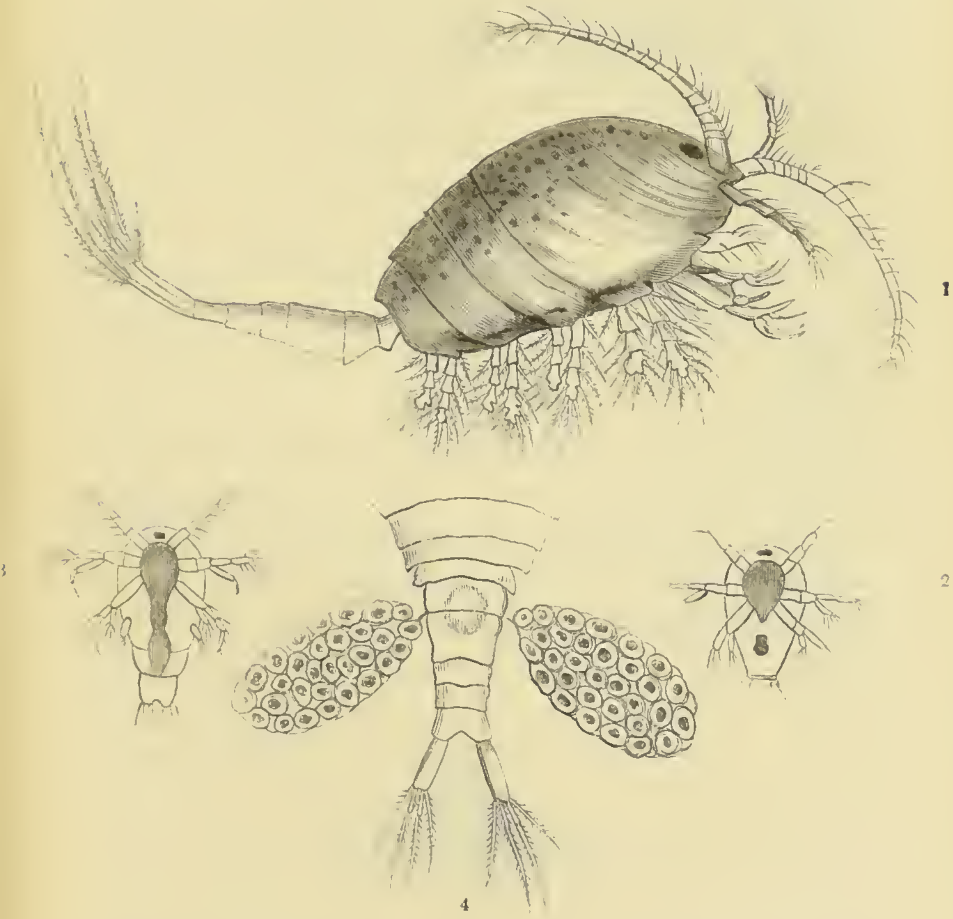
Commensurate with the importance of their office are the means employed to multiply their numbers and preserve their race. No *insect* is permitted to produce more than a single brood during her life, but a female cyclops has been proved to give birth to at least ten successive broods in the short space of three months, averaging perhaps thirty or forty for each brood.

Even in the remarkable provision made by nature to secure the eggs from danger till the young are born, we perceive a similar purpose to secure the numerical strength of this diminutive race of beings. The females are, in almost every species, furnished temporarily with a pair of capacious external sacs appended on each side of the body, and which, when distended, are frequently much larger than the entire animal. In these curious receptacles the eggs are carried about until mature, the sacs then fall off and perish. In one genus (daphnia), however, a different proceeding is adopted, the eggs being securely lodged in a kind of pouch situated upon the back, beneath the shell, under the safeguard of which they are hatched, and the young progeny safely nurtured for four or five days, until strong enough to procure their own subsistence.

Still, however, there are other difficulties to be surmounted of no ordinary character circumstanced as these creatures are, living in scanty ponds and shallow ditches, always subject to be dried up by the summer's drought,—how is the race to be preserved till the returning rain produces a new pool that claims to be repeopled? Yet so it is; the eggs, though dried, retain vitality enough to start again to life when plumped by moisture, and to complete the miracle, it has been proved that every egg, once fertilized, produces fertile beings down to the sixth generation without further impregnation.

Mons. Jurine, a celebrated Genevese naturalist, who carefully watched the hatching and increase of the *Cyclops quadricornis*, represented in the woodcut (fig. 90), has given a calculation showing the amazing power of reproduction possessed by this species. He states "that he watched one female isolated, lay ten times successively; but in order to be within bounds, he supposes her to lay eight

Fig. 90.

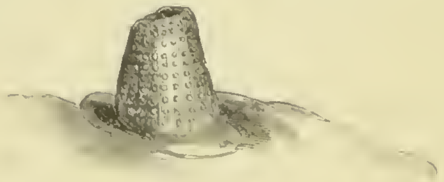


times within three months, and each time only forty eggs; at the end of one year this female would have been the progenitor of four billions, four hundred and forty-two millions, one hundred and eighty-nine thousand, one hundred and twenty descendants!

The young animals, when they leave the egg, are widely dissimilar in shape from the parents that produced them. Of this we have an example in the *Cyclops* figured above (fig. 90), which when first hatched are of an oval shape, and have only three pairs of feet (2); on the seventeenth day after moulting their skins, they assume the appearance represented at 3, and it is not before the third moulting that the creature assumes the adult form (1).

The second division of these crustaceans is to the naturalist even more interesting than the preceding, inasmuch as it is among the creatures composing it that the geologist finds the only existing resemblances of countless myriads of creatures long blotted from the page of creation, and whose history, without such help, it would have been impossible for modern science to unravel.

Fig. 91.



Throughout the very earliest strata that proclaim the appearance of animal life upon this globe, mixed up with the remains of various strange and unknown forms of living beings belonging to those times when "THE SPIRIT OF GOD MOVED UPON THE FACE OF THE WATERS," are millions of remarkable fossils called Trilobites, remnants of creatures evidently crustacean in their nature, having broad, flat, shield-like heads, furnished with large compound eyes (fig. 91), testifying that the fiat "LET THERE BE LIGHT," had been already issued to the world when they existed.

The body of these creatures was composed of from six to twenty-four articulated segments, terminated by a broadly-expanded plate, representing the tail. They likewise possessed the power of rolling themselves up into a ball after the manner of the common wood-louse, as is evident from multitudes of specimens found in that condition. Still no traces of legs or antennæ were ever observable on their remains. It was evident from the corals and other marine objects associated with these fossils that they were aquatic animals, and, from their numbers, that they were gregarious in their habits, from which circumstances Professor Ansted * conjectures that the different species probably lived for the most part in shallow water, not buried in mud, but floating near the surface, with their under sides uppermost, feeding on the minute, and perhaps

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* The Ancient World; or, Picturesque Sketches of Creation, by D. T. Ansted, M.A., F.R.S., F.G.S. London: John Van Voorst.

microscopic, animalcules that usually abound in such localities.

The only animals at present in existence that correspond with creatures so organized, are the crustaceans with leaf-like feet (*Phyllopodous branchiopoda*), varying in number from twenty to upwards of a hundred, and forming small ciliated plates. These animals are likewise furnished with compound eyes, and many of them crowd the waters in which they are found to such an extent, that when taken up by violent winds they have fallen like a shower from the air.

Under such circumstances the *Artemia salinus*, or brine shrimp, which we shall select as an example of this group, assumes singular importance, the lingering representative of a vast creation passed away. The artemia (fig. 92), as described by Mr. J. V. Thompson,* is a very small and delicate animal; when full grown about half an inch in length, of considerable transparency, slightly tinged with yellow, and with a highly polished surface. Nature having constructed them with members solely adapted to swimming, they seem to be in perpetual pursuit of prey, gliding with an almost even motion through the water, and moving with equal indifference and facility with the sides, back, or under surface uppermost, the shape of the animal, the undulating movements of its fins, and its glossy appearance, giving it a very elegant appearance. These crustaceans, after leaving the egg, undergo a metamorphosis very similar to that of the cyclops: its different stages of growth are represented in the figure.

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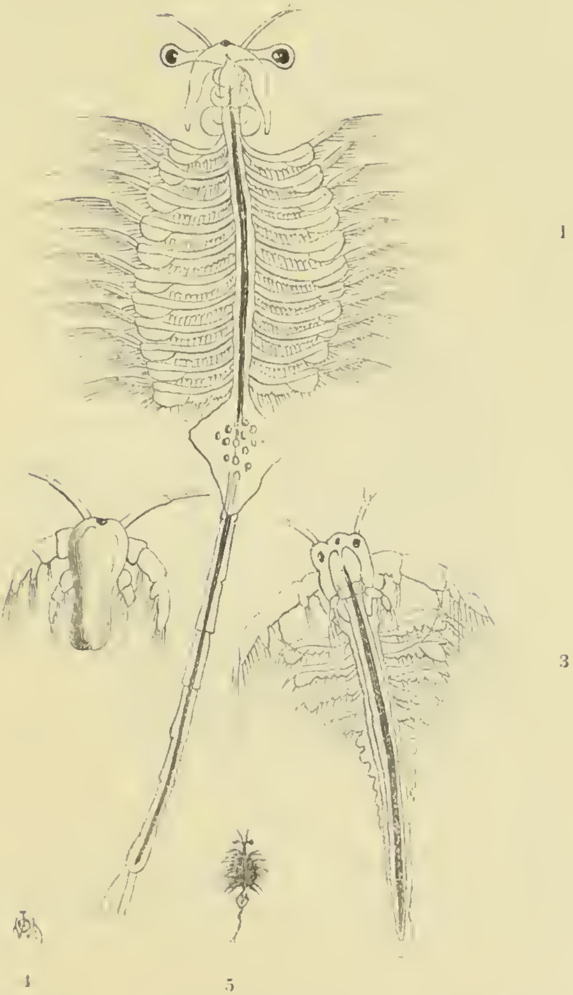
* Linn. Trans. vol. v. p. 11, J. V. Thompson.

Fig. 92.

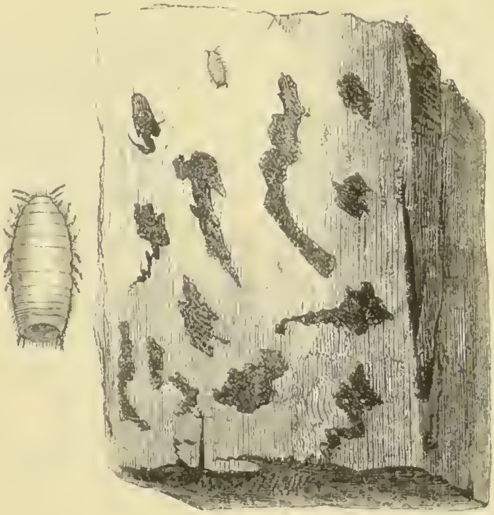


The next order of crustaceans (ISOPODA) is distinguished by the great similarity of the structure of the legs, upon whatever segments of the body they may be developed. Of these, perhaps, the common wood-louse, *Oniscus*, well known to every one of our readers, is a familiar example. This genus, we need scarcely say, is terrestrial in its habits, always, however, frequenting damp secluded situations. Cellars, rotten trees, or beneath blocks of wood or stone among wet and putrefying herbage, are its favourite resorts, and in such localities it industriously carries on its humble but important business, which is to devour, and thus remove corrupting or decaying vegetation. Almost all the crustaceans belonging to this order are, in fact, scavengers, and widely do their duties extend. Some inhabit ponds and stagnant ditches, as for example, the freshwater shrimp, *Asellus;* the generality, however, are marine, and are met with abundantly in every sea where the work of cleansing demands their presence. One of these oceanic species, *Limnoria terebrans* (fig. 93), has earned for itself particular notice, albeit doubtless quite unconscious of having done anything extraordinary. Among the many objects requiring the attention of Nature's police, are the wrecks of mighty forests floated down by rivers to the sea, where they might drift about for ages, till the very waves were cumbered with the accumulating load; but waiting for them are mighty hosts of active labourers ready to remove such useless masses. Of these the little *Limnoria,* figured in the next page, is one of the most indefatigable; legions of them attack the hardest blocks, and boring into them in every direction, like the termite ants in another element, make up by their numbers for their insignificant size. Proud man! it is a pity that they so much lack discrimination—

that they will mistake your ships for floating logs—your dykes, your piers, your dock-yard gates for rotten wood—can you not teach them to respect your labours while dealing with the general havoc of a world?

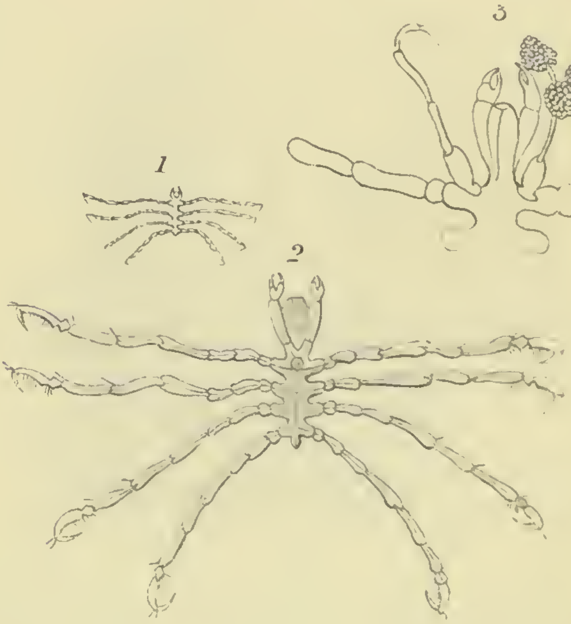
The Læmodipoda form a small, but very curious, order of Crustaceans, exemplified by the *Pycnogonidæ*, an extensive family, not uncommon on our coasts, and of which Dr. Johnston, of Berwick, has published an excellent account. The *Pycnogonidæ* (fig. 94), according to the researches of that eminent naturalist, are all marine animals. They conceal themselves among sea-weed and corallines between tide-marks, under stones within the lowest tide-line, and they are occasionally dredged from deep water. Their motions are remarkably slow, and, as it were, painful, to our apprehension; hence

Fig. 93



it is obvious that their prey must be either dead animal matter, or living animals as defenceless as themselves, an inference which is confirmed by the structure of their mouth. Their body is slender and crustaceous, not much thicker than their limbs, and although divided into segments, they seem quite immovable upon each other, so that the whole trunk is rigid. Upon the head there is a small tubercle surrounded by four simple eyes, but in some species these are not to be detected. The legs are all alike in form, and calculated solely for creeping; they are eight-jointed, and provided at their extremities with one or two strong claws, sometimes aided by subsidiary ones moving in the same direction.

Fig. 94.



The females are apparently fewer in number than the males, or are at least much seldomer met with; they are distinguished by having a pair of spurious legs in addition to those common to both sexes, which originate from the inferior anterior margin of the first thoracic segment, and are appropriated to the purpose of holding and carrying the eggs (fig. 94, 3). These are collected into globular masses, enveloped in a thin skin or membrane, each mass firmly adherent to the spurious or oviferous leg, and consisting of a congeries of numerous round ova. The changes which the individual may undergo from birth to maturity are unknown.

Some forms (*Cyamus ceti*) very nearly resembling the above, are parasitic upon the whale, to such an extent indeed, that the entire back of those leviathans of the deep seems covered with their multitudes.

The *Corophium*, a kind of sand-hopper (fig. 95), may be taken as an example of the next order (*Amphipoda*, whose name is derived from the circumstance of their having their legs of two kinds, some being claw-shaped, adapted for holding, while the rest are formed for swimming.

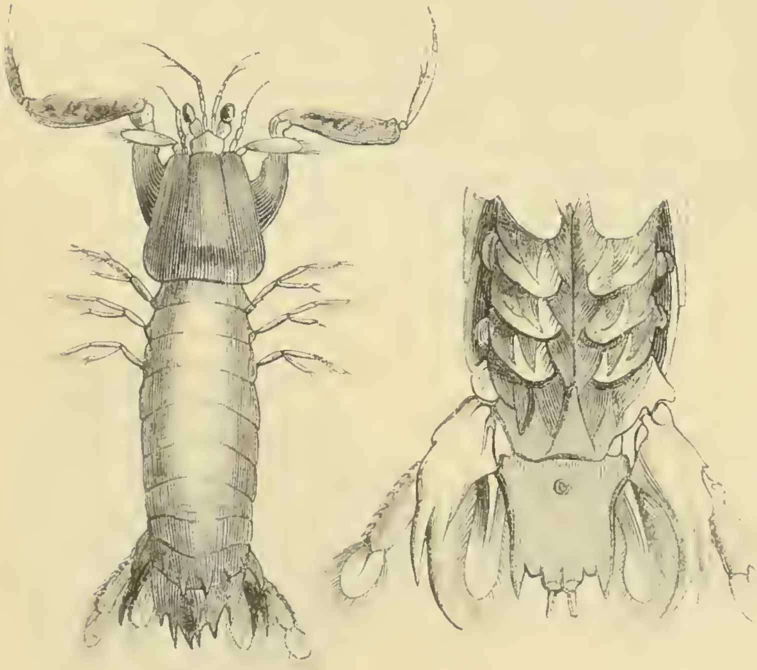
These creatures inhabit the sea-shore, and may frequently be seen on a fine summer evening, skipping about in countless thousands, so as, indeed, to have the appearance, at a little distance, of a low cloud hovering above the sand, just upon the verge of the retreating water, which is their hunting ground, and where they are indefatigably employed in devouring all the garbage that the tide has left; doubtless a rich supply of nourishment. According to M. Orbigny, however, they are by no means satisfied with this ignoble prey, but wage a destructive war upon the sea-side worms, which they combine together to attack. Dead fishes, and even human bodies cast up by the waves, furnish a not unacceptable banquet, and they are accused of devouring mussels and other shell-fish.

Our fresh waters likewise furnish similar forms in great abundance; they swim, as it were, by jerks, bringing their tail, which is terminated by variously shaped appendages beneath the breast, and then suddenly striking with it backwards, so as to launch themselves along at every stroke.

Fig. 95.

Nothing can be more impressively evident to the mind of the naturalist than the unity of plan conspicuous throughout the animal creation. In vain have thousands of species, and even genera, after having performed the parts assigned to them in the economy of this world, perished from the earth to be replaced by other forms adapted to a changed state of circumstances; in vain have countless ages passed away, and been rolled up "as a scroll that is written"—still we recognise on every page the same characters, teaching the same great lesson, that the laws of Nature are immutable, steadily advancing with unswerving rigour towards the accomplishment of one grand design, and, consequently, that the FRAMER of those laws is "from everlasting to everlasting, and his years shall not fail." In the same manner we are able to perceive in the animals belonging to the existing creation, undeniable evidences of the works of the same hand throughout, and of this few creatures give more decided proof

Fig. 96.



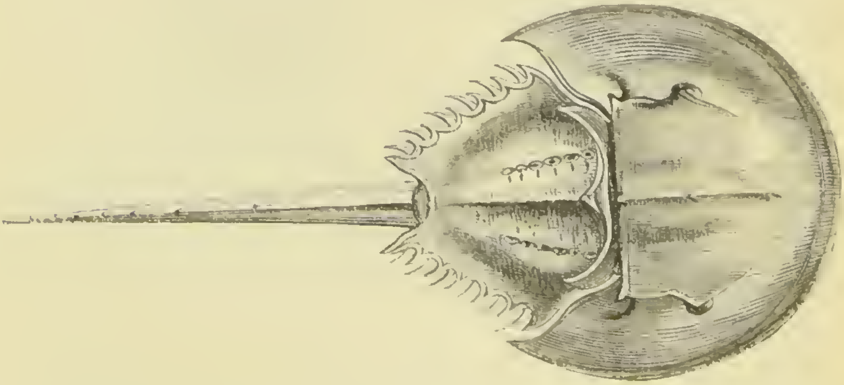
than the Crustacea belonging to the next group we have to consider.

Any one who will take the trouble to compare the figure of the Mantis, or leaf-insect, described in a preceding chapter, with the appended portrait of the Squilla, or Sea-mantis, as it is perforce called (fig. 96), would almost think the weapons of the insect-gladiator had been borrowed by the inhabitant of the ocean, so accurately is the same pattern followed in the construction of both.

The Squills, under various generic modifications of form, constitute the order STOMAPODA, so called from the circumstance of their ambulatory feet being congregated in the immediate vicinity of the mouth. These feet, however, are of secondary use, the principal instrument of locomotion being their broad and vigorous tail with which they doubtless dart actively about in the deep waters of tropical seas to which their presence is confined.

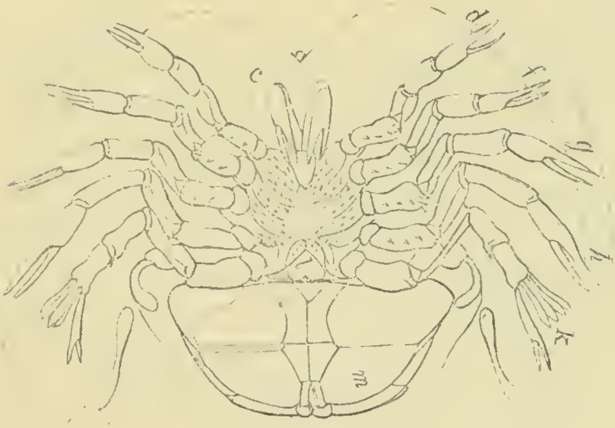
In thus enumerating the principal forms of Crustaceans, it would be unpardonable to pass over in silence the most strangely organized of this strange class;—animals, indeed, of such heteroclyte appearance, that it seems difficult to find a place for them

Fig. 97.



in the series. These are the King-Crabs of the Moluccas (*Limulus*), which from their aspect would seem rather to belong to the age of Trilobites than to the present creation. The back of these remarkable animals (fig. 97 A) is entirely covered by two broadly expanded plates, convex above, and concave beneath; the anterior of these, which is much the larger of the two, forms a wide semilunar shield, on which may be remarked two oval-shaped eyes of considerable dimensions, each being composed of very numerous granular facets; besides these, however, near the front part of the shield, may be observed two small simple eyes, resembling those of the scorpion or spider.

Fig. 98.



The second division of the shell is united to the preceding by a broad joint; its shape is triangular, truncated posteriorly; its lateral edges are notched and toothed, and in every notch, beginning from the second, there is attached a movable spine.

The tail is a long bayonet-like weapon, jointed to the centre of the second piece of the shell, of extreme hardness, and having its edges armed with long jagged teeth: of this pretty instrument man has not failed to avail himself; it forms a ready-made spear-head, well worthy of the savage who wields it, the wounds which it inflicts being truly terrible.

The limbs, however, form the most extraordinary part of the structure of these creatures. The mouth (fig. 98) has in front of it a little triangular lip, supporting two pincer-like antennæ (*c*,) each of which is bent like an elbow near its middle: there are no jaws, but the haunches, or upper segments of the legs, that immediately surround the mouth, are covered with sharp spines or teeth, and perform all the functions of the ordinary parts of a mouth. The legs are twelve in number, six on each side of the mouth, the four anterior pairs (*d*, *f*, *g*, *h*) being terminated by didactyle forceps; the fifth pair (*k*) presents quite a different structure, having at its base an additional appendage, while the last joint is furnished with five movable plates, besides a small pair of forceps fixed at the end of a movable stem.

The last order to be noticed comprehends the largest members of this extensive class, and from the circumstance that many of them are important to mankind, as affording him nutritious food, the forms and habits of the various members composing it are familiar to every one. The most important characters whereby they are distinguished from the preceding orders, are the following:—They are invariably furnished with ten legs, a circumstance from which the entire order to which they belong receives its name, DECAPODA, the anterior pair, and frequently two or more of the succeeding ones, being armed at their extremity with strong pincers. The head and thoracic portion of the body are covered by a large shell, consisting of a single piece, called the carapax, or shield, and the mouth is provided with ten pairs of organs, which being exactly comparable neither to legs nor jaws, but intermediate both in form and function to both, are, by universal consent, called foot-jaws. They breathe, moreover, by means of numerous branchiæ or gills, which are fixed to the roots of their legs or jaws, and are lodged in a special cavity, situated on each side of the body, protected by the carapax, or shell.

The decapod crustaceans are divided by zoologists into three principal groups, named respectively, MACROURA, BRACHYURA, and ANOMOURA, words which, however euphonious they may be in Greek, are rather distressing to the ear, we shall therefore translate them into plain English, as meaning LONG-TAILS, SHORT-TAILS, and QUEER-TAILS. Of the former we have examples in the Shrimp, the Cray-fish, and the Lobster; the second is exemplified by the Common Crab, and the third comprises the Hermit Crabs and others of similarly anomalous structure.

Every one is acquainted with the general appearance of the common lobster (*Astacus marinus*) which we select as an illustration of the organization and economy of the macroura. This creature is strictly marine in its habits, inhabiting the deep waters near steep and rocky coasts. Its whole conformation is adapted for swimming; to leave its native element and come out upon the shore would be to it impossible; but at sea it swims about with extraordinary agility, darting backwards if alarmed some eighteen or twenty feet at every stroke of its powerful tail, while its legs are too feeble to be at all efficient as instruments of locomotion. Living upon garbage, it is easily caught in traps baited with tainted meat; and at least a million are supposed to be imported annually to supply the tables of London alone.

Fig. 99.

In order, however, to understand the economy of these Crustaceans, it will be necessary to examine the specimen we have selected limb by limb, that we may be able to appreciate the various functions assigned to the different members, and see to what various uses *legs*, or claws as they are vulgarly termed, may be turned.

These legs are, in fact, merely the appendages to the individual segments of the body, which we have seen already assume such anomalous shapes in Annelides—Insects and Spiders—but in the class before us their arrangement is so simple, that it is impossible to mistake their real nature. Beginning with the head then, we find a pair of organs attached by movable joints, to the sides of the first segment, but which, instead of being shaped like legs, sustain the organs of vision, having at their extremities compound eyes, constructed after precisely the same pattern as those of insects, only that the multitudinous corneæ are not hexagonal but square.

The appendages to the two succeeding segments present a very different structure, forming the antennæ, instruments of sensation, of which we shall speak hereafter.

The next series constitutes the apparatus of foot-jaws, appointed to supply the mouth with food; the external of these approaches most nearly in its form to the ambulatory legs, but is nevertheless armed with sharp teeth along its inner margin; the succeeding ones become more and more membranous in their structure until we arrive at the innermost pair, which suddenly assume a very different texture, being as hard as porcelain, and presenting cutting edges as sharp as those of a pair of shears, wherewith to cut the food preparatory to its being taken into the mouth. Arising from the basal joint of all these foot-jaws is an antenna-like organ resembling the palpi of insects, and most probably destined to perform similar functions.

The appendages to the next segment are the largest and most powerful of all, so that they are called *par excellence* the *claws* or *chelæ* of the lobster; their size is, indeed, enormous, and each being terminated by a tremendous pair of "nippers," their gripe is formidable. To a superficial observer these two claws would appear to be alike both in structure and function, although they are in reality appropriated to very different uses. The nippers of one will be found to be furnished with broad, blunt, tuberculated teeth, wherewith, as by an anchor, to hold fast the sea-weed in agitated water; the teeth of the opposite claw are small and sharp, adapted to cut and divide the substances upon which they seize.

To the four next succeeding segments are appended the "ambulatory feet," which are extremely slender and feeble; the two anterior pairs, moreover, being terminated by forceps, they are anything but adapted to walking.

Beneath the abdominal portion of the animal, usually called the tail, these organs are again totally changed: any largely developed legs in this situation would, by interfering with the free movements of the tail, materially have hindered the creature while swimming; they are therefore reduced to a very rudimentary size, and, although they are called false-feet, are principally useful in affording attachment to the eggs which the female carries about with her.

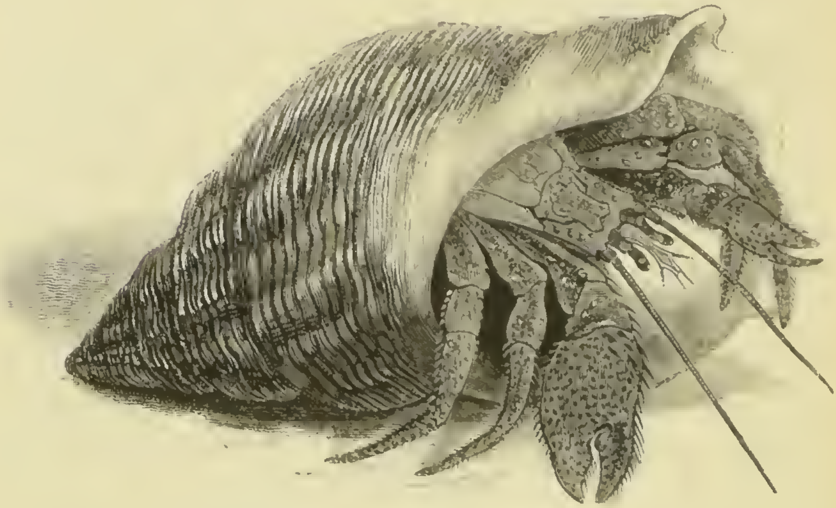
Lastly, we come to the tail itself, an instrument which it is impossible to examine without being struck with admiration at the perfection of the contrivance evinced in this admirable oar; yet even this is composed of a central ring, or segment, with its lateral appendages, or legs, so that from one end of the body to the other, all the limbs are merely modified forms of the same element of the external skeleton.

In order to appreciate more fully the importance of the above observations, let us contrast with the lobster, selected as an example of the *macroura*, or long-tailed crustaceans, one of the *anomoura*, or queer-tails, and for this purpose we will take the soldier crab (*Pagurus streblonyx*) one of the queerest of the tribe.

The soldier crabs, or hermit crabs, are appointed to inhabit the shore, where, upon the shelving beach, close in the vicinity of the tide-line, they follow the vocation assigned to them by nature. The locality they frequent is a very dangerous one, and they would speedily become the prey of some of their numerous enemies had they not been instructed to secure themselves from their foes by an ingenious stratagem. Apparently well aware of their unprotected condition, they adopt a very unusual mode of life, living entirely in the old forsaken shells of whelks and other similar univalve mollusks that they may find suited to their size, which they change from time to time, and nothing can be more ludicrous than to see them in search of a new abode, prying diligently into the empty shells upon the beach, which they carefully examine one by one, and frequently slipping their tails out of their old habitation to fit it into a new one, speedily, however, retreating to their former house if the new one does not seem to suit (fig. 100).

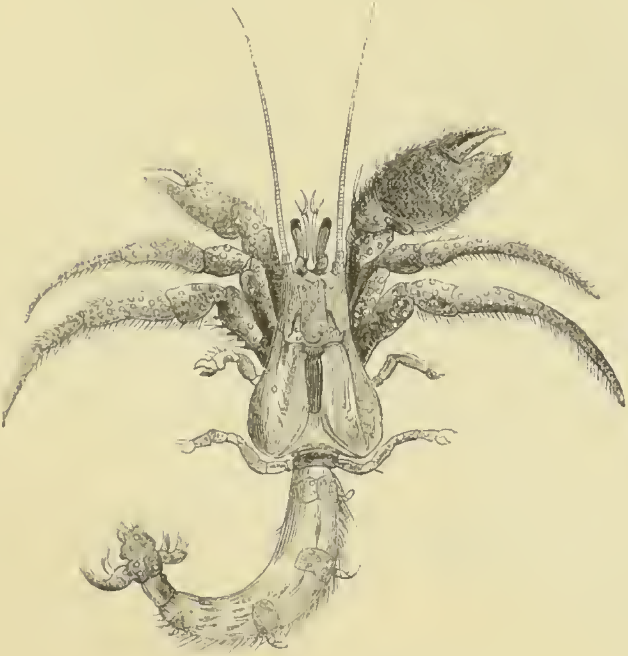
To accommodate the hermit crab to such strange circumstances, a very slight modification of the condition of the limbs above enumerated is requisite. All that portion of the integument situated behind the carapax, which is itself quite rudimentary, is left of a soft and leathery texture, containing, however, imbedded in its substance, a few irregular cal-

Fig. 100.



careous plates (fig. 101), but these are so situated as to allow the tail freely to pass into the windings of its

Fig. 101.



shelly abode ; the false feet beneath the abdomen are suppressed, and the tail, although still composed of the same pieces as in the lobster, has them so distorted as to convert the organ into a grappling apparatus, whereby the creature takes secure hold of the whorls of its domicile, and thus drags it along.

The two hinder ambulatory legs are reduced to a very rudimentary condition, being, in fact, only useful for the purpose of enabling the hermit-crab to change its position in its retreat, while the two anterior strong and massive pairs, on which the whole labour of locomotion must devolve, and which, moreover, in addition to the weight of the animal, have to drag about its ponderous residence, form enormous levers, sharpened and hardened at their points, and in every way fitted to the ponderous load.

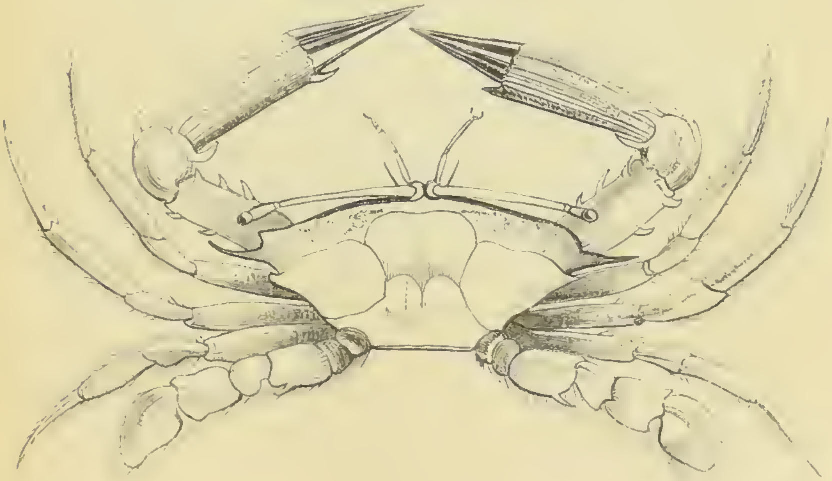
Lastly, by no means the least curious part of the contrivance is found in the structure of the great *chelæ* or claws, which are always of very unequal size, one being remarkably short and slender in proportion to its bulky fellow; had the two been of equal magnitude, it would have been impossible for them both to be withdrawn into the mouth of the shell, but by the plan adopted, when the pagurus retires within its retreat, all its limbs may be neatly packed up, and the larger claw, which then forms the door of the citadel, presenting itself like a giant's fist at the portal, defies the most daring invader.

Let us now turn our attention for a moment to the *Brachyura*, or short-tailed decapods, comprising the various genera of crabs, and see in what manner they are fitted for their appointed duties.

The inferior races of marine crustaceans are all strictly aquatic, inhabiting the sea, in which element alone they can exist. The crabs, however, which may be regarded as the most highly organized of the whole class, are the chosen occupants of the shores of ocean, where they co-operate with countless other forms, in eating up the refuse of the waves. Their whole structure is in accordance with this occupation. The tail, no longer wanted for swimming, is reduced to a rudiment, the fin at its extremity is entirely removed, and as though what there is left of it might incommode the movements of the animal, it is neatly folded up beneath the expanded thorax (fig. 102), and removed from observation. The thorax, on the contrary, is enormous, and the ambulatory legs of proportionate strength, enabling it to run about upon the beach in search of food, one of the most active and indefatigable officers of Nature's coast-guard.

Still, although thus the sentinels of the shore, the tract which they have to occupy is of great extent, and very variable nature, requiring corresponding alterations in their structure and habits; some are launched out a little way to sea, or find upon the gulf-weed, or other floating masses, means of subsistence; these are the swimming-crabs (*Pinnipedes*),

Fig. 102.



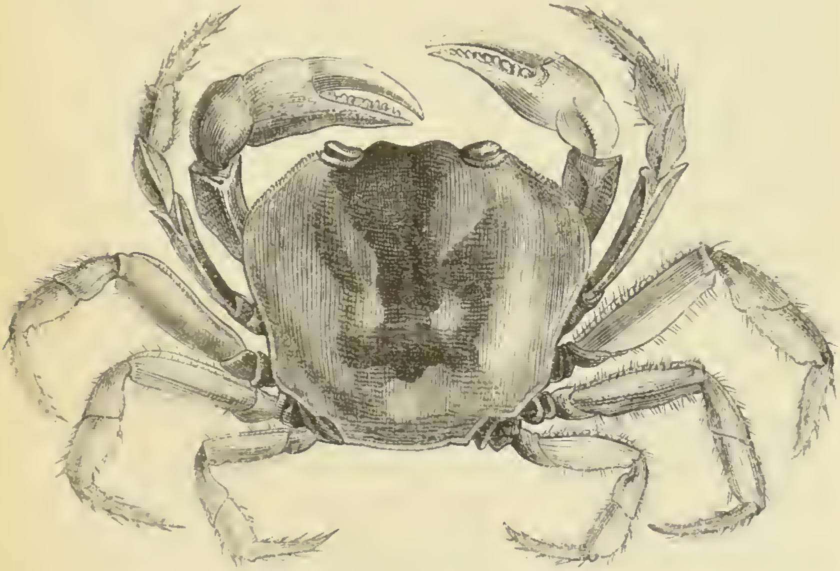
but the oar that they employ in swimming is no longer the tail; by simply flattening out the last joints of the hindmost pair of legs (fig. 102) these are converted into most efficient paddles.

In the strictly littoral species, such as the common crab, these paddles are suppressed: yet even these sometimes prefer deep waters and a rocky coast. The terrestrial kinds are remarkable for their power of running with equal facility in any direction, backwards, or forwards, or sideways; they can even ascend inclined planes, or climb the perpendicular rock by means of the strong sharp-pointed claws with which their ambulatory legs are armed. Whilst walking or running their great claws, or *chelæ*, are held up in various attitudes, and sometimes with a peculiar gesture, to which many genera owe their names; some, for example (*Gelasimus*) have earned the appellation of "calling crabs," because they seem to be always beckoning to some party at a distance; others (*Calappa*) are the "modest crabs," always concealing their faces with their broad claws as a bashful damsel might with her fan: others, again, more threatening in their aspect, seem to "square" at you with their *chelæ*, like so many pugilists, and not unfrequently by this manœuvre effect their escape from a timid foe.

But being thus once established on the shore, it is easy to extend the duties of these active beings still further, and some are actually dispatched inland to aid the labourers there in their great work. Thus, for example, the *calling crab* above alluded to, digs for itself a deep burrow in the ground, near the sea-side, in which it dwells, as likewise do the *Ocypods*, or *running crabs*, so called because, such is their speed (if we believe the accounts of some travellers), that to catch one a man must gallop after it on horseback, and shoot it with a pistol!

The most celebrated of these terrestrial species are the land-crabs of the West Indies (*Cancer ruricola*), which pass the greater portion of their lives among the mountains in the interior of the country, where they live in deep holes, hiding themselves during the day, and only quitting their retreats in the evening: many of them take up their abode in church-yards and other depositories of the dead, a circumstance which, although it renders them objects of abhorrence to the inhabitants of the districts

Fig. 103.

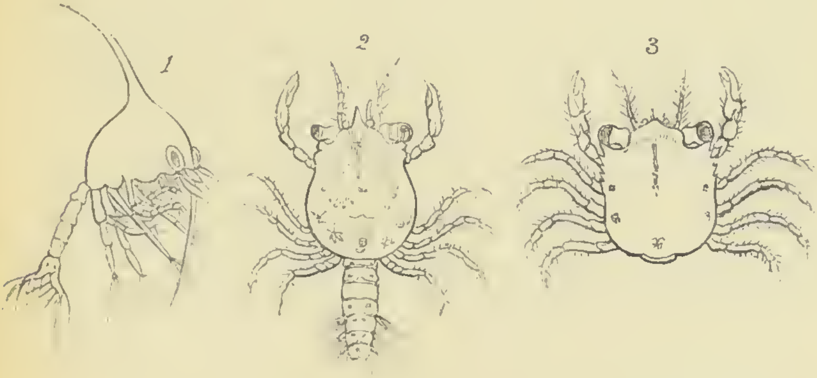


where they abound, serves to illustrate the instincts and the habits of the class of which they are members. Once a year, that is in May or June, at the commencement of the rainy season, they assemble in vast numbers to pay a visit to the sea, their native element, for the purpose of depositing their eggs. Whilst employed in making this important pilgrimage, so imperative is the law that urges them to their destination, that no obstacle seems insurmountable to their perseverance; they generally travel by night, and rest during the day, until they reach the coast, and fulfil the object of their journey by laying their eggs in the sea; this accomplished, they return to their retreats in the mountains.

It may, perhaps, be natural here to inquire why these land-crabs are compelled to take an annual journey of such length and so hazardous, instead of laying their eggs in their mountain fastnesses—a question which involves another important part of the history of these animals, namely, the metamorphoses through which they have to pass during their progress from the condition in which they leave the egg to their adult form, and for this part of their history, science is indebted to the researches of J. V. Thompson, Esq., of Cork. According to the observations of this gentleman, the young crab on first leaving the egg, so far from resembling its parent, presents quite a different structure, insomuch that it might easily be mistaken for one of the lowest forms belonging to the crustacean class; and it in fact has been described and figured by zoologists as one of the Branchiopoda under the name of *Zoea* *pelagica.* In this condition the young crab appears under a very curious and grotesque aspect (fig. 104[1]). Its body is hemispherical, and its back prolonged upwards into a horn-like appendage; the legs are not yet developed, with the exception of the two last pairs, and these, far from resembling the limbs of the future being, are ciliated like those of a Branchiopod, and only adapted to swimming; the tail, which is longer than the body, is furnished with no false feet, while the terminal joint is crescent-shaped, and armed with long spine-like appendages; it is, therefore, in every respect, an aquatic animal, and could only exist in the water.

In a more advanced stage of development, the young crab assumes a totally different shape (fig. 104[2]); the eyes, instead of being sessile, become pedunculated, the cephalo-thorax, or carapax, flattened, the tail expanded, and provided with false feet, and the antennæ, chelæ, and ambulatory legs assume their normal shape. Still the little creature can only swim, its legs are too feeble to admit of any other

Fig. 104.



mode of progression, and the tail, which is natatory, is not as yet folded up beneath the thorax:—in this condition the young crab has been known to naturalists under the name *Megalopa*.

A subsequent moult gives the little creature the appearance of the adult crab, and then only does the abdomen become concealed beneath the thoracic portion of the body, and the animal fitted to emerge from its native element. Seeing, therefore, that the water must necessarily form the cradle of the young crustacean, it is by no means surprising that so toilsome a pilgrimage is undertaken in the case we have been relating.

From the fact that many genera of crustaceans thus undergo a metamorphosis, it is evident that, as among insects in their larva state, a frequent change of their external integument is, even in this class, imperatively necessary, and from other circumstances this operation needs to be repeated more frequently during the life of the crustacean than is necessary among the other articulata. The growth of the insect is completed as soon as it assumes the imago-state, for reasons that have been already explained: but in the crustacean, growth is permitted to proceed, until many of them, the crabs and lobsters, for example, arrive at very considerable dimensions, such as, in the case of insects, could never be permitted without dangerous results. To provide for the growth of a crab, would seem, however, to be a problem of no easy solution, encased as these creatures are in marble armour, which is as incapable of growth or expansion as the mail of steel worn by our warlike forefathers. The only plan to be adopted in the case of the crustacean, is to allow it at stated intervals to cast off its old investments, and, after advancing another step in growth, while thus liberated from its confinement, reclothe itself with a new suit adapted to its increased size. This is, in truth, the simple plan adopted; when pinched for room it casts aside its old cuirass, extricates its legs from their greaves and jack-boots, and, in the course of a short time, fits itself with others adapted to its enlarged bulk. All this process, when so enunciated, might appear simple enough, but a little consideration will convince our readers that there are difficulties connected with the process of no ordinary kind; that to divest itself of such a cuirass as the complicated armour wherewith its body is coated must be a matter of some difficulty; and as to drawing off its boots, any one who examines, for a moment, the conformation of its legs and claws will perceive that no ordinary boot-jack would enable it to draw off these portions of its dress. Were it that the pieces were broken and cast off piece-meal, indeed, the operation would be less wonderful, but the shell of the creature when thrown off is found to be almost entire, nor is there any crack or fissure visible, to explain how such legs could have been withdrawn from such garments; and when to this we add that all the tendons and levers provided for the movements of the different pieces of the shell, whereunto the muscles were attached, the very teeth from the stomach, and the corneæ of the eyes, it must be evident that this portion of the history of the Crustacea is not a little curious.

For the following interesting observations upon this subject, which we shall give in his own words, science is indebted to our zealous countryman, Jonathan Couch, Esq., of Polperro.*

"When about to throw off its exuviæ, the crab commonly retires to some secret place, in the neighbourhood of rocks that will afford it shelter when unable to escape from danger or defend itself from enemies. Its craving appetite seems also at this time to be suspended; but the particular subject of my observation differed from others, in wandering into a crab-pot at this period in search of food, and being known by the fishermen to be what is called *peel*, that is, about to throw off its crust, it was transferred to the safe keeping of the store-pot on Saturday, July 30th, where, on the morning of August 1st, it was found just then delivered from its covering. As quickly as possible, and without injury, the living crab and its empty representative were brought to me, and the following is a description of the exuviæ.

"The longest diameter of the carapace was 6¾ inches; compass of the largest chela and length of the flap or tail, severally 3¾ inches; the individual was a female, or what is termed by fishermen, a Bon Crab. The carapace was sound, except on its under surface, where, in its ordinary state, a curved line passes backward from the jaws to the hinder part of the body. When caught on the 30th, this portion was observed by the fishermen to be loosened, and now the portion included between this waved line and the sternal plate was entirely separated, and fallen inward. The sheaths of the antennæ and palpi perfect; one eye gone, the other remaining with the transparent covering perfect, the stalk loosely attached; the tail and all its appendages perfect; the sternal plate beginning to break across in the middle, leaving to each portion a pair of legs on each side; but this not being a complete or natural separation may have been produced by the weight of the limbs alone, or the efforts of the animal. The chelæ and legs perfect in all their attachments, the membranes unbroken; and the flat bones which occupy the middle of the muscles, and serve them for tendons or points of attachment for motion, were uninjured, and fastened to each joint, their distant extremities hanging loosely in the cavity of the case of the limb. The coverings of the branchiæ were perfect to their minutest extremities, and besides the internal coat of the stomach, the whole internal skeleton of the animal was thrown off without fracture or displacement.

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* Magazine of Zoology and Botany, vol. i. p. 341.

"The living representative of this wonderful skeleton, measured 7½ inches in its longest diameter, the compass of the largest chela, and length of the flap or tail 4 inches; the weight 24½ ounces, being 5½ ounces less than an ordinary crab of the same dimensions weighed with it for comparison. It was plump, having much the appearance of a lump of dough, enclosed in a membrane, and it was also equally soft, with scarcely any power of motion;

appearing sensitive only when pressed on the under surface of the carapace. The colour above was red, beneath a pale yellow, the flap purplish, the bristles on the legs fully formed, but soft. On cutting open the legs and chelæ, the bony plates to which the muscles are attached, and which serve for tendons, were found as soft as wet parchment, and towards the extreme joints could not be distinguished with certainty. On breaking off the largest chela at the joint where the animal itself is accustomed to separate it when injured,* the usual membrane formed towards the body, and no discharge took place, but a watery fluid poured copiously from the surface towards the limb, which was thus soon left empty, speedily becoming capable of being blown up with air like a bladder. On proceeding to dissect the body, a similar circumstance took place, the fluid running off in so large a quantity that I regretted, when too late, that I had not taken the precaution to have measured it. In a few minutes the body had so sunk into one mass, that I was unable to distinguish the separate parts. At the lower and inner part of each joint of the chelæ and legs, an opening remained in the form of a slit, through which the flat central bony plate found in the empty crust had been withdrawn, which opening of course must be closed when the shell is finally consolidated."

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* In these crustaceans a very curious provision exists, whereby they are enabled, if one of their limbs be mutilated by any accident, to throw off the remaining portion at a point indicated by a small suture in the shell without danger or loss of blood; even on any sudden alarm they will not unfrequently "cast their claws" at this part, as every fishmonger knows. It is not, however, so well known that when a claw is thus amputated, at the part indicated, by this piece of natural surgery, it will grow again, a new limb sprouting from the stump, which, in the course of a short time, equals in efficiency, if not in size, the one that was discarded.

Such is the condition of the crab immediately after extricating itself from its shell; its subsequent proceedings are as follow,—The newly liberated animal has at first strength enough to crawl off to a place of safety. Its first instinct, after securing a retreat, is to absorb as much fluid as will distend its organs, and their common covering, now as flexible as velvet, to the full extent of their capacity, by which means the deposition of crustaceous particles is made in accordance with the dimensions of its newly-acquired bulk, which, in an ordinary sized crab, Mr. Couch found to exceed the former by at least an inch in its longest diameter, and in all its dimensions in the same proportion; in the earlier stages of growth, however, the increase of bulk at each exuviation is, of course, relatively to the size of the animal, much more considerable.

The simple history of this wonderful phenomenon is consequently intelligible enough. As the time for casting its shell approaches, the crustacean becomes sickly, and its flesh flabby, and unfit for food; to use the expressive phraseology of the fishermen, it "pines away," until its limbs shrink to less than three-fourths of the size of the investing shell, from which the fleshy body gradually becomes detached throughout its whole extent. In this condition, according to Reaumur's observations on the cray-fish (*Palæmon serratus*, Leach), the creature abstains from all solid food, and the carapace and abdominal segments appear to offer less than the usual resistance to the pressure of the finger. Shortly afterwards the animal appears restless, and rubs its legs against each other; it then throws itself on its back, agitates its whole body, and then distends itself, by which the membrane joining the carapace to the abdomen is burst, and this great dorsal plate is raised. Some degree of rest follows these first struggles, but after a short time the animal again puts all its organs in motion, the carapace is seen to rise gradually from its legs beneath, and in less than half an hour the animal has extricated itself from this portion of its slough. By retracting its head, the antennæ, eyes, jaws, and legs are withdrawn as from a case, the extrication of the last being the most difficult and complicated operation. The hinder parts are withdrawn with less difficulty, the head is conducted below the carapax, and the tail being thrown off by a forward motion, attended with a brisk and distensive action, the creature is seen divested of all encumbrances, and the case is left unbroken as if no struggle had ever taken place within it. The creature now dilates its body as described above, by the absorption of water; and whilst in this distended condition, the cutis, or living skin, now its only investment, begins rapidly to secrete another shell, moulded upon the expanded surface of the body, and in everything, excepting size, precisely similar to its predecessor.

Thus, then, we have arrived at the limits of a third vast circle of creation; before we enter upon another let us pause for an instant and look back. Awful scene! and yet presented for our contemplation year by year as years roll on, still changing, still the same; perishing always, and yet always new! Worms, Myriapods, and Insects of ten thousand forms, all busily employed, in water, earth, and air, doing the high behests of HIM who marshals their innumerable hosts, and sends them forth. His agents, each filling its appropriate sphere, and testifying to the mind of MAN, the sole intelligent spectator of these wonders here on earth, that

> La gloria di colui che tutto muove,
> Per l' universo penetra, e risplende.

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